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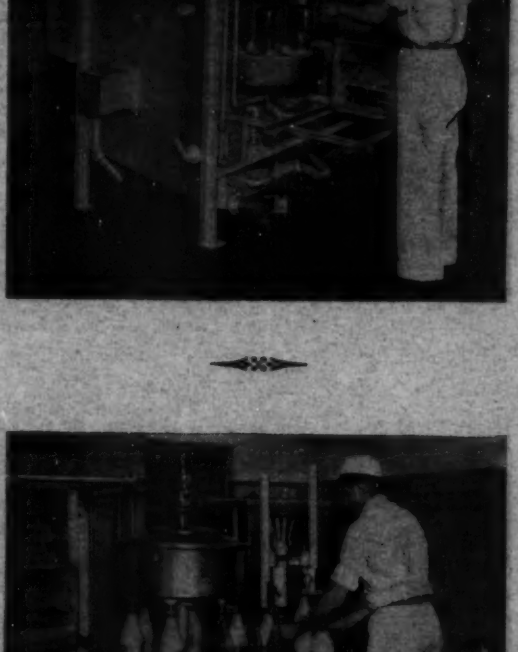

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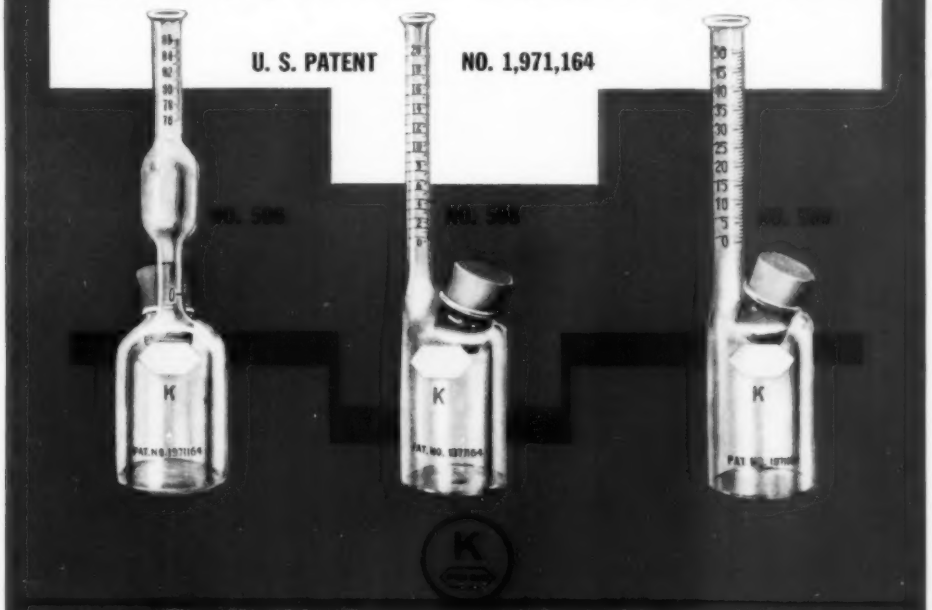

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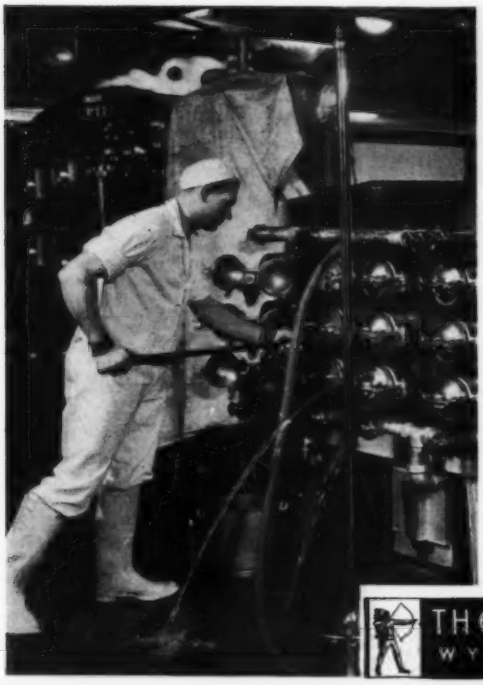

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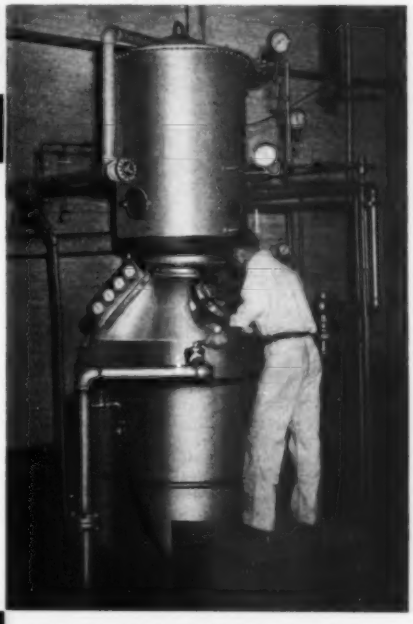

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JOURNAL OF DAIRY SCIENCE

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THE EFFECT OF ADVANCED LACTATION IN THE COW ON THE PHYSICAL AND CHEMICAL COMPOSITION OF THE MILK

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In herds under bacteriological supervision where it is the practice to milk cows longer than seven or eight months following parturition, it has been found that physical and chemical changes occur in the milk of certain animals and that these changes are usually more common to all quarters. The object of this paper is to show that these characteristic changes in the composition of the secretion during advanced lactation in many instances are probably produced by causes other than bacterial infections.

In the literature pertaining to mastitis there are very few data concerning this phenomenon, or the results of periodic laboratory examinations of milk during the complete span of a lactation period. Johns (1), Johns and Hastings (2), and Hastings and Beach (3) reported the results of the examination of the milk of young cows (complete lactations) free from streptococci by the use of indirect chemical tests and bacteriological methods. In a group of 31 young cows studied during their first lactation periods, Hastings and Beach (3) found that 14 persistently yielded abnormal milk, occasionally from only a single quarter. Klein *et al.* (4, 5) showed that milk samples from noninfected cows in the intermediate stage of lactation had a lower pH and chlorine concentration than the milk from cows in either the earlier or the later stage of lactation. They reported (5) that the high values in pH, chlorine content, and leucocyte counts in a group of special cows probably were associated with advanced lactation. Plastridge (6), Edwards (7), and Udall and Johnson (8) found that the milk from uninfected cows during the later months of milking or when the cows began to dry off gave higher pH determinations than the milk in their earlier lactation periods. These observations have been partly confirmed by a different approach in dairy research primarily concerned with the physical and chemical changes occurring in the milk as the result of prolonged milking periods. It has been reported that the acidity (9), the chlorine content (10), and the curd tension (11) of the milk may be increased during advanced lactation. Furthermore, especially in pregnant cows, there occurs a more marked decrease of

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the milk flow (12) during the later period of milking. This decrease in the milk yield is accompanied by an increase in the percentage of fat (13), a reduction (14) in the size of the fat globules, and the development of a bitter taste attributed to the secretion of a fat lipase (15) which also interferes (14) with the churning ability of the cream.

The significance of these chemical and physical changes of the milk as related to prolonged milking has been briefly discussed by Espe in his recent book "Secretion of Milk" (16). He says: "With the increasing percentage of fat in the milk commonly associated with advancing lactation there also occur other characteristic changes, including an increase of most of the milk solids except lactose. Occasionally the salt content of milk secreted at this time tends to increase markedly; causing certain investigators to suggest that after several months' lactation the composition of the milk tends to approach the composition of blood. They do not mean to infer that the organized bodies in blood, such as the red and white corpuscles, appear but that instead of the epithelial cells of the alveoli synthesizing the constituents occurring in normal milk, the normal selective absorption of the semi-permeable cell membrane is reduced, permitting certain constituents of the blood to pass into the milk unchanged. In fact, it has even been suggested that serum globulin and possibly albumin may appear in the milk in increasing amounts at this time. In addition to a sharp rise in chloride content there is an increase of pH, as well as enzyme and catalase values."

From the literature just cited it is not clear at what period of milking the cow is considered to be in advanced lactation. It has been reported, however, that the acidity (9) remains fairly constant from the second through the seventh month; the fat (13) increases after 7 or 8 months of milking, and the effect of pregnancy (12) becomes apparent by a reduction of the milk yield after a five months' gestation period. Hence, if a cow conceives to a service 2 months following parturition, these changes (increase in pH, percentage of chlorides, and leucocyte count) may be expected to occur in the milk of certain cows after a lactation period of 7 or 8 months' duration. Thus after this time the animal may be considered to be in advanced lactation.

MATERIAL

The data for this publication were obtained from three widely separated herds in which an attempt has been made to control mastitis by the monthly laboratory examination of the fore milk. As originally planned, this study was to be continued indefinitely, so the present observation was merely incidental to the main objective. The herds have been under observation for the following periods: herd A for 36 months, and herds B and C for 26 months. In herd A all the cows infected with Group I streptococci (*Streptococcus agalactiae*) (17) were eliminated, whereas in herd B they were quarantined in a separate barn, and in herd C they were segregated in the

same barn with the normal cows but were milked last. In each herd special precautions were employed in the stable management, and the milking operation was carefully supervised.

In this study only those cows were selected in which the milk failed to show the presence of mastitis streptococci or alteration due to staphylococci or miscellaneous organisms.

METHODS

When a bacteriological examination of the milk was made, the preliminary laboratory work was conducted at the respective farms. The routine methods employed have already been reported in detail (18). The samples of the fore milk (3 or 4 cc.) upon collection were kept chilled, and 1 cc. of a 1:10 dilution of it was plated in blood agar. The leucocyte films also were prepared on the premises and the chloride dilutions set up.

RESULTS OF THE LABORATORY EXAMINATION OF THE MILK

In Table 1, under section A, are given the results of the laboratory examination of the milk from 112 quarters of 24 cows conducted during the first four months of lactation. Section B of this table includes the results of the laboratory examination of the milk from these same cows after lactation

TABLE 1

Laboratory tests of samples of milk from cows, (A) at the beginning, and (B) at the end of the same lactation periods, and (C) at the beginning of the succeeding lactation periods

No. of cows	No. of quarters	pH			Percentage of chlorides		Leucocyte count			Bacteria count				
		6.6	6.7	6.8 and over	Under 0.140 per cent	Over 0.140 per cent	0 to 300,000	300,000 to 1,000,000	1,000,000 and over	10 to 3,000	3,000 to 10,000	10,000 to 20,000	20,000 to 40,000	40,000 to 100,000
(A) During first 4 months of lactation														
24*	112	109	2	1	101	11	108	4	.....	97	13	.....	2	.....
Percentage		97.3	1.8	0.9	90.0	9.8	96.4	3.6	.....	86.6	11.6	.....	1.8	.....
(B) After 8 months or more of lactation														
24*	112	41	47	24	15	97	64	36	12	47	31	21	11	2
Percentage		36.6	42.0	21.4	13.4	86.0	57.2	32.2	10.7	42	27.7	18.7	9.9	1.8
(C) At beginning of the succeeding lactation														
16**	64	53	10	1	52	12	60	4	.....	47	11	5	1	.....
Percentage		82.8	15.6	1.6	81.2	18.7	93.8	6.2	.....	73.4	17.2	7.8	1.6	.....

* The milk of 4 of the 24 cows was examined through two complete lactations.

** 8 cows were not available for examination at this lactation, since 4 had been sold, 2 had died, and 2 had not yet calved.

periods of 8 months or longer. Under section C are presented the results of the laboratory examination of the milk from 64 quarters of 16 of these cows at the beginning of the succeeding lactations.

It will be noted in Table 1 under section A that the majority of the samples showed a pH of 6.6 and that the majority of the chloride determinations were not above 0.14 per cent. In 96 per cent of the samples the leucocyte counts (neutrophils) were not over 300,000 cells per cc. of milk. Under section B, however, it is shown that approximately 63 per cent of the samples gave a pH reading of 6.7 or above, while in 86 per cent the chloride determinations were above 0.14 per cent. In 32 per cent of the samples the leucocyte count varied between 300,000 and 1,000,000 cells per cc. (neutrophils), but in 10 per cent it was above 1,000,000. In the latter group the bacterial counts were correspondingly higher, and the predominating microorganisms were staphylococci (other than *Staphylococcus aureus*) and diphtheroids. However, the milk from 15 other cows in the three herds, with bacteria counts nearly as high in the late stage of lactation, showed very little change in pH, percentage of chlorides, and the leucocyte count. This fact is evidence that high bacteria counts and the physical and chemical changes under discussion are not necessarily associated with each other. Hence it may be assumed that these changes are not always caused by bacterial infections. Support for this belief is provided in the observation that usually, in udders infected with staphylococci and miscellaneous microorganisms, not all quarters show these characteristic changes. In this series of cases, however, the animals included in the table usually showed more uniform cell counts and changes in the chemical composition of the milk from all quarters.

It is significant, as noted under section C, that in the early part of the succeeding lactations some of the cows produced a milk of lower quality than that of their previous lactations (increase in pH and percentage of chlorides), thus indicating some impairment of the udder which occurred during the previous lactation. It should be mentioned that 4 cows developed mild cases of mastitis caused by Group III streptococci (17) (*Str. uberis*) 3, 4, 6, and 8 months respectively after the last bacteriological examination of the milk reported in Table 1, under section C.

DISCUSSION

The results of the laboratory examination of the fore milk from 112 quarters of 24 uninfected cows in their late lactation periods, as compared with the determinations from these cows in the early stage of the same lactations, showed a marked increase in alkalinity, percentage of chlorides, number of leucocytes, and, occasionally, bacteria counts. This change in the reaction of the milk during prolonged milking was not common to all the cows in the three herds. Usually it was more noticeable in the milk from the older animals, but the same phenomenon was observed in the milk from 10

first-calf heifers. The change in the character of the secretion from some cows during prolonged milking may plausibly be explained by the theory that the lining alveoli in certain udders were more permeable to the constituents of the blood. It should be mentioned here that a majority of the determinations (section B) were obtained from cows during periods of equable weather, thus eliminating extreme climatic changes as contributory factors responsible for the abnormalities of the milk obtained in advanced lactations.

The literature (9–16) suggests that in advanced lactation the physical and chemical composition of the secretion becomes altered so that the milk produced at this time perhaps may be regarded as abnormal. This alteration in the normal constituents of the secretion may in some way influence the effectiveness of the inhibitory or bacteriostatic substance present in normal milk which is primarily concerned in the protection (19–22) of the udder. In other words, if the normal protective mechanism of the milk or udder is affected, the common udder flora or the more infective types of streptococci or staphylococci should develop more readily. On the other hand if the potency of the inhibitor remains unchanged the increased permeability of the cell membrane may allow the passage of the constituents of the blood in certain cows to reach the udder unchanged and thereby supply nutritive material which renders the environment more favorable for bacterial growth. Thus it is likely that animals in advanced lactation, due to the changes in the character of the secretion, may be more prone to infection or to an increase in the general bacterial population of the udder than cows milked for shorter periods. Furthermore, the slight increase in the leucocyte count in addition to the change in the physical and chemical composition of the secretion suggests that prolonged milking may also be responsible for the induration found in the udders in which there is no history of mastitis.

In the study of the pathology of "nonspecific mastitis" Peterson and his associates (23) reported chemical and physical changes occurring in the udders of young cows during one or more lactations which were not attributed to streptococci or the more infectious types of staphylococci. They suggested, therefore, that nonspecific mastitis might be caused by an unknown agent, possibly a filtrable virus. Before nonspecific mastitis can be attributed to some special etiological agent, other factors—including the effect of advanced lactation—should be carefully considered. Such a study should include the effect, if any, of heredity on the permeability of the udder; the effect on the udder of hand versus machine milking; the effect on the udder of a forced high milk yield as compared to a more normal yield, and a controlled study under normal conditions of the effect of the physiological secretion of milk in conjunction with a thorough survey of the bacteriological population of the udders of the cows studied.

In regard to the data here presented, it remains for future observations

to determine if it is a better practice for the dairyman to shorten the lactation period of the cow in an attempt to preserve her udder, or to continue the milking into advanced lactations, with little consideration for the general health of the cow and the unborn calf.

SUMMARY

1. The results are given of the laboratory examination of the milk from 112 quarters of 24 cows during the early and late stages of their lactation periods.

2. It is shown that the milk produced by certain cows after 8 months of lactation had a higher pH, percentage of chlorides, and cell content than the milk the same cows had produced during the first 4 months of the same or succeeding lactation periods.

3. In view of these observations it is suggested that prolonged milking is conducive to certain physical and chemical changes in the secretion which affect the normal bacteriostatic substance in the milk. These changes, perhaps, not only increase the susceptibility of the gland to bacterial multiplication but also may result in a low-grade physical change in the secretory tissue of the udder and eventually shorten the total production life of the cow.

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FACTORS AFFECTING THE PASSAGE OF LIQUIDS INTO THE RUMEN OF THE DAIRY CALF. I. METHOD OF ADMINISTERING LIQUIDS: DRINKING FROM OPEN PAIL VERSUS SUCKING THROUGH A RUBBER NIPPLE[1]

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INTRODUCTION

The unthrifty appearance commonly observed in young dairy calves in modern dairy herds has been attributed, in many cases, to the deviation from "nature's way" of feeding. As substantiating etiological evidence, attention frequently is called to the fact that calves permitted to nurse cows are generally free of ailments usually observed in calves fed from open pails.

The thriftiness of calves permitted to remain with a nurse-cow may be ascribed to several factors, namely: the frequent consumption of relatively small amounts of milk; ingestion of milk at a constant temperature; the intake of gases that are normally present in the milk in the udder; slow consumption of the milk permitting much saliva to be mixed with it; and the passage of the milk directly to the abomasum. This last factor is the basis for much exploitation by manufacturers of certain calf feeds and calf feeders.

The contention is that when calves drink from pails, the milk is forced into the rumen where it undergoes abnormal decomposition causing physiological disturbances. In view of the paucity of experimental evidence this investigation was designed primarily to ascertain the extent to which pail feeding permitted and sucking prevented the passage of milk and other liquids into the rumens of calves.

REVIEW OF LITERATURE

Several calf feeders have been devised and used in an effort to simulate the natural method of milk consumption. Nearly all of them have a rubber nipple of some type. Several investigators (4) (6) (13) (15) reported that feeding calves with a good artificial feeder produced better growth and development than did feeding from pails. There is, however, little definite fundamental physiological information that may explain the observed results.

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From a study of the functional importance of the esophageal groove of young calves Schalk and Amadon (8) reported results that throw some light on the problem. By means of gastric fistulae in three calves about ten days of age, these investigators determined the course followed by the milk when it was drunk from a pail and when it was sucked through a nipple made from rubber finger cots. When the milk was taken through a nipple, none except a spurt as nursing began escaped into the rumen. Thus it was concluded that the liquid was coursing through the esophageal groove directly into the omasum and abomasum. On the contrary, during the act of drinking, the major portion of the milk ingested escaped from the proximal extremity of the groove into the rumen and reticulum.

Confirmatory evidence is available from work with other ruminants. It was observed that in suckling kids (1) (11) (12) and lambs (5), milk and other liquids traversed the esophageal groove to the abomasum. However, regurgitation of some of the material into the reticulum and rumen occurred within one hour after consumption.

According to Dukes (2) the groove of the young calf functions also as a conduit for water during the first few weeks of life. After that time, the response of the esophageal groove to water begins to wane permitting it to enter the rumen and reticulum.

EXPERIMENTAL METHODS

Two systems of feeding, (a) the common open pail from which the calf drinks the milk and (b) a nipple calf feeder,* the essential feature of which is a valved rubber nipple through which the calf sucks the milk, were used in this investigation. In the preliminary phases of this work each calf was fed by one of the methods from three days to 10 or 14 days of age, when it was slaughtered. Pasteurized milk from a mixed herd of Guernseys, Jerseys and Holsteins was fed. The daily allotment, approximately 10 per cent of the body weight of the calf, was given in two feeds, morning and evening.

The methods employed in determining whether or not the liquid entered the rumen and reticulum were also twofold. In the preliminary work each calf was slaughtered and the stomach contents examined. The last feed of milk was stained a brilliant green with a coal tar dye** to facilitate identification in the stomach. Precautions were taken in felling the calf, in segregating the compartments of its stomach and in excising the stomach to prevent the possible transfer of milk from one section to another. The obvious disadvantages of this technique necessitated adoption of a more satisfactory method.

* Coyner feeder pail, sold by Armour and Company, U. S. Yards, Chicago, Ill.

** Food coloring manufactured by Blanke-Baer Extract & Preserving Co., St. Louis, Mo.

The second and preferable procedure used was observation through rumen fistulae. These were established in seven male calves (Table 1). Since the surgical technique employed was somewhat different from that generally described, the procedure is presented in detail as follows:

The operative area on the left side was clipped, shaved, washed and painted with iodine. A local anesthetic, two per cent procaine solution, was injected along the line of incision located midway between the tuber coxae of the ilium and the vertebral attachment of the last thoracic vertebra. The incision, directed downward and slightly forward, was oval in shape, two to three inches in length, and started as near as possible to the transverse process of the fourth lumbar vertebra. The skin, fascia, muscles and peritoneum were incised and spread open. The rumen wall was then picked up and a portion of it was attached to the edges of the skin with interrupted linen sutures. The center portion of the sutured rumen protruded and separated the wound edges of the skin thus preventing their healing and closing the opening. As soon as the rumen and skin edges had firmly united, which occurred in four to five days, the sutures were removed and the rumen was opened.

The wound was washed daily with an antiseptic solution followed by an application of urea wound dusting powder (urea with Potassium-Oxy-Quinolin Sulphate) on all the wound surfaces until complete healing had occurred.

In one calf a transverse instead of a vertical fistula was made. It was

FIG. 1. Observation through the transverse fistula of an experimental calf.

four inches in length, and located as near as possible to the transverse processes of the lumbar vertebrae and just above the upper posterior border of the obliquus abdomnis externis muscle. The surgical procedure and the post operative care was the same as that used on the other calves. This method seemed to be more satisfactory as there was less discharge of the rumen contents through the fistula.

Observations were made by direct visual inspection. The interior of the rumen was illuminated by means of a diagnostic light which is small enough for convenient manipulation within the cavity. Inspections were made, as shown in Figure 1, while the calf was consuming the liquid.

As in the preliminary investigations, the fistulated calves were fed pasteurized, mixed herd, milk twice daily. The systems of feeding the milk were alternated from time to time throughout the duration of the experiment. The number of subjects and periods of observations are indicated

TABLE 1

Period of observation and initial systems of feeding fistulated calves

Herd No.	Breed	Age		Initial feeding method
		Started	Concluded	
		Days	*Days*	
C–29	Holstein	57	164	Pail
C–30	Holstein	29	94	Pail
C–32	Holstein	23	155	Nipple
C–34	Holstein	22	129	Pail
C–36	Holstein	19	126	Pail
C–37	Holstein	17	107	Nipple
349–B	Jersey	33	176	Pail

in Table 1. During the early stages of the work, only milk and water, were given. Later, however, grain and hay were fed.

EXPERIMENTAL RESULTS

The preliminary results from post-mortem observations, shown in Table 2, indicate that when the milk was taken through a nipple by the young calf, none of it could be detected in either the rumen or the reticulum. When the milk was drunk from an open pail, in several cases some of it escaped into the rumen. Subjects E–3 and E–4 revealed no evidence of any milk in the first two compartments of the stomach. The amount of milk found in the rumen and the reticulum of calves E–1 and E–2 was a very small proportion of the total quantity consumed. In all cases a small amount of curd was observed in the omasum. The greatest amount of the consumed milk, however, was always found in the abomasum.

Lumps of curd were observed in the abomasum of every calf. There was considerable variation in the consistency of the lumps with different individuals. Though no specific measurements of hardness were made,

TABLE 2

Location of milk in stomach of calves slaughtered after consuming milk either from open pail or through nipple

Method of feeding	Number of calf	Breed	Sex	Age when slaughtered	Location of milk		
					Rumen and reticulum	Omasum	Abomasum
				Days			
Open pail	E–1	Holstein	Male	13	+	+	+
	E–2	Guernsey	Male	9	+	+	+
	E–3	Jersey	Male	10	–	+	+
	E–4	Jersey	Male	13	–	+	+
Nipple pail	E–5	Holstein	Male	11	–	+	+
	E–6	Holstein	Male	10	–	+	+
	E–7	Holstein	Male	13	–	+	+
	E–8	Guernsey	Male	11	–	+	+
	E–9	Guernsey	Male	13	–	+	+

+ = milk or curd present.
– = no milk or curd present.

from general examination the curd from the nipple fed calves appeared firmer and tougher.

The foregoing preliminary results relative to the channels followed by the milk ingested by different methods were substantiated from observations of calves having rumen fistulae. As indicated in Table 3, when the calves

TABLE 3

Frequency of the entrance of milk into the rumen and reticulum and the amount entering when calves are fed either from open pail or through nipples

No. of calf	Open pail feeding					Nipple pail feeding		
	Total observations	Milk entered rumen				Total observations	Milk entered rumen	
		Observations		In amts.* > 25 mls.			Observations	
	No.	*No.*	*Per cent*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*
C–29	186	36	19.4	3	8.3	24	0	0
C–30	73	40	54.8	16	40.0	26	4**	15.4
C–32	149	93	62.4	41	44.1	84	6**	7.1
C–34	118	92	78.0	59	64.1	75	0	0
C–36	125	68	54.4	22	32.4	79	0	0
C–37	78	20	25.6	2	10.0	104	0	0
349–B	216	0	0.0	0	0.0	65	0	0
Total	945	349	36.9	143	41.0	457	10**	2.2

* Amount of milk entering rumen was estimated.
** Small quantity, never more than 3 mls., during first swallows.

were fed milk from an open pail, a portion of the milk occasionally passed into the rumen and reticulum. The frequency of entrance ranged from zero in the case of 349–B to 78.8 per cent in the case of C–34. Considering the entire group, milk entered the rumen in 36.9 per cent of the cases. If

349–B, in which no milk entered the rumen, be excluded, the frequency of entrance is increased to 47.9 per cent.

The amount of milk entering as well as the frequency of entrance is important to the well-being of the calf. As shown in Table 3, in only 41 per cent of the cases in which the milk escaped into the rumen, the amount exceeded 25 mls. Though it was difficult to estimate the volume of milk in the rumen, the quantity rarely exceeded 50 per cent of the total ingested. The greatest proportion of the milk escaping into the rumen entered during the first few seconds of drinking.

When the milk was sucked through a valved nipple, the results were somewhat more consistent than when drunk from a pail. In only 2.2 per cent of the observed cases did any milk flow into the rumen. The amount entering never exceeded 3 mls., which spurted from the esophageal groove during the first several swallows.

The water, consumed by either of the two methods, entered the rumen more frequently than did milk ingested in a similar manner. As shown in Table 4, when water was drunk from an open pail, the frequency with which it passed into the rumen was high and relatively consistent with different individuals. In contradistinction when water was sucked through a nipple, the frequency of entry into the rumen was not only low but also variable.

TABLE 4

Frequency with which water entered the first compartments of the stomachs of calves when either drunk from pail or sucked through a nipple

No. of calf	Drinking from open pail			Sucking through nipple		
	Total observations	Water entered rumen		Total observations	Water entered rumen	
		Observations			Observations	
	No.	*No.*	*Per cent*	*No.*	*No.*	*Per cent*
C–29	45	38	84.4	8	0	0.0
C–30	16	16	100.0	8	3	37.5
C–32	78	77	98.7	16	15	93.7
C–34	86	82	95.3	16	4	25.0
C–36	80	79	98.7	30	10	33.3
C–37	33	32	97.0	22	1	4.5
349-B	77	75	97.4	27	5	18.5
Total	415	399	96.1	127	38	29.9

The amount of water escaping from the esophageal groove was proportionally great when taken by the pail method. The major portion of the water consumed usually flowed into the rumen. When the nipple method was used, only a relatively small proportion of the volume consumed entered the rumen.

DISCUSSION

It is obvious from the foregoing results that milk frequently escapes into the ruminal and reticular cavities when it is drunk from an open pail.

The time of entrance of the greatest amount was usually during the first few seconds of drinking. The detrimental effects of the presence of milk in these first two compartments of the stomach of the calf have been emphasized from nutritional and physiological standpoints. Schalk and Amadon (8) stated that milk undergoes digestive changes only within the abomasum; hence the passage of milk into the rumen and reticulum merely delays the assimilation of nutrients needed by the body. Akssenowa (1), however, assumed that enzymes of the abomasum of kids were also present and active in the rumen. This assumption was based on the observation of the transference of milk from the abomasum into the rumen. Though it is possible that similar transfers may take place in calves, this phenomenon was not observed in any of the foregoing experimental subjects. Mangold and Usuelli (7) reported that milk is deleterious to rumen infusoria. This may interfere with the normal functions, digestive or otherwise, of the rumen. Even if it is assumed that milk undergoes decomposition in the rumen, the extent to which the products may be absorbed directly remains a moot point. In accord with the observations of Schalk and Amadon (8) it was observed that the milk diluted with other fluids eventually passes from the ruminal cavity. Thus it seems that a consideration of the problem from any angle leads to the conclusion that the presence of large amounts of milk in the rumen and reticular cavities of calves probably retards digestion and assimilation.

Further indictment of pail-feeding milk is frequently made on the basis of digestive disturbances resulting from abnormal decomposition of the milk in the rumen. This, no doubt, is true when the major proportion of the ingested milk escapes into this cavity. The relative infrequency with which large quantities of milk entered the rumen suggests that this point has been overemphasized. In only one calf, C–34, did the milk frequently enter in prodigious amounts throughout the observation period. This was the only case in which the presence of milk in the rumen could be associated with diarrhea.

When the rumen wall was opened, considerable putrid curd was present in the cavity. Caseous necrosis was present on much of the area surrounding the esophageal groove. Nearly all the milk consumed from a pail gushed from the cardia directly into the rumen. Upon changing to a nipple, the necrotic condition gradually disappeared and scours subsided within several days. The crux of the problem is probably a matter *a priori*. Did the passage of the milk into the rumen initiate the pathological condition of the esophageal groove, or did some other factor cause the improper functioning of the groove permitting the passage of nearly all the milk into the rumen, thus aggravating the condition?

Apparently the older the calves the greater the frequency of entrance and the larger the volume of milk passing into the rumen; yet physiological disturbances rarely occur in older calves if they are receiving a normal

ration of hay and grain. When calves are restricted to a whole milk ration over a prolonged period, curd frequently accumulates in the rumen (14). Gaseous putrefaction or other abnormal decomposition follows causing marked disturbances. Thus the nature of the ration fed in conjunction with the milk evidently is one factor determining the magnitude of the deleterious effects of milk in the rumen.

In view of the possible detrimental results of milk in the rumen, the obvious advantage of the nipple systems of feeding is the passage of milk directly from the cardia to the reticulo-omasal orifice without any significant spillage into the ruminal and reticular cavities. Furthermore, Espe (3) has suggested that the nipple system enhances complete coagulation in the abomasum as a consequence of slow ingestion and thorough mixing with saliva, which increases viscosity. This completeness of coagulation prevents flooding of the small intestine, which is rather sensitive. This, however, is not entirely in harmony with Sheehy's (9) recommendation that the milk be diluted with water in order to alter favorably the character of the rennin clot so as to facilitate rapid digestion. Any system that promotes quick coagulation with the formation of a soft curd would be considered ideal; yet this is contrary to *in vitro* observations (10). The extent to which consumption of milk through a nipple effects this desirable phenomenon in the abomasum of the calf is problematical.

The frequency with which water, when taken from an open pail, flows directly from the cardia into the rumen cavity is in accord with the report of Dukes (2). Evidently after the calf is several weeks of age the tonicity of the esophageal groove is not affected by water. Apparently nature has synchronized the time that this liquid begins to enter the rumen with the age at which the calf begins to consume roughage and concentrates in appreciable amounts.

When water is consumed via nipple, the relative infrequency of its passage into the rumen cavity and the small amount entering indicates that sucking produces a stimulus that causes the esophageal groove to function. Perhaps it is as abnormal for a calf to consume water by sucking as it is to ingest milk by drinking.

There is much variation in the responses of various calves and in the same individual at different times. The causes of these variations are numerous and indefinite. Some of the probable factors involved are being studied further.

SUMMARY

1. The frequency of the passage of milk and water into the ruminal and reticular cavities of calves was studied by administering the liquids from open pails and through valved nipples. Observations were made by slaughtering and by inspection through rumen fistulae.

2. There were marked variations in the responses of the calves.

3. When milk was ingested from an open pail, it frequently entered

the rumen in small amounts but rarely in quantities equivalent to the major portions consumed.

4. When milk was sucked through a valved nipple, it rarely entered the rumen cavity and never in significant amounts.

5. Water consumed from an open pail frequently flowed from the cardia into the rumen in amounts almost equal to the quantity consumed.

6. Water sucked through a nipple occasionally spurted into the rumen but in relatively small amounts.

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THE RELATION OF PHOSPHOLIPIDS TO FAT IN DAIRY PRODUCTS

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It is apparent from a study of the literature on the phospholipid content (as lecithin) of dairy products that there is a wide variation in the per cent "lecithin" between different milk products and also in the per cent "lecithin" in the fat extracted from the different products by the Mojonnier method.

This paper, in a measure substantiates previous work on the "lecithin" content of dairy products and offers an explanation for the results obtained.

REVIEW OF THE LITERATURE

Chapman (4) found that the per cent "lecithin" in the fatty extract obtained by the Mojonnier method was highest in buttermilk (20.25%), next highest in skim milk (10.78%) and milk (1.6%) and lowest in cream (.43%). This agrees with the work of Horrall (8) who reported as follows: buttermilk (19.66%), skim milk (13.91%), raw sweet cream (.428%), milk (.85%), butter from raw sweet cream (.232%). Holm, Wright, and Deysher (6) reported the following amounts as per cent lecithin in the product: whole milk, .0337; skim milk, .0169; 41% cream, .1816; butter, .1819; buttermilk, .1872. When calculated on the basis of per cent "lecithin" in the fat, these figures show close agreement with the results of Horrall and Chapman.

Perlman (13) showed that the phospholipid content of the fatty extract of fresh cream shows a variable decrease with the increase in the fat content of the cream indicating a variable loss of the original milk phospholipids in the skim. The lipide phosphorous per unit of fat was found to decrease between 58 and 80 per cent fat. Close agreement with the foregoing was reported by Jack and Dahle (10).

An extensive review of the literature on the "lecithin" content of dairy products is beyond the purpose of this paper and hence will not be presented; however, should one be desired, see Horrall (8) and Holm, *et al.* (5).

METHODS AND RESULTS

The term phospholipid is used to designate the fat like substances containing phosphorus that are extracted from milk and its products by the Mojonnier method. For convenience of comparison of the results obtained here with other results, the phospholipid was reported as per cent "lecithin" both in the product and in the fat extracted from the product using the for-

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mula given by Horrall (8), which closely approximates those of Bird, *et al.* (1), Holm, *et al.*, (6), and others.

Phospholipid was determined as described by Horrall (8) except that the fat was ashed carefully over a Fisher burner and that Nessler tubes were used instead of a colorimeter. Samples were run in duplicate; on the basis of per cent "lecithin" in the product, the difference between duplicate determinations varied from 0.000 per cent to 0.019 per cent and averaged 0.0046 per cent for all samples. Blank determinations were run frequently to insure freedom from contamination.

The milk and other dairy products used were as delivered to or made in the plant (with the exception of the cream and skim milk which were separated from tank milk in the laboratory) and all were of excellent quality. Milk was separated at 120° F. in a DeLaval S-16 separator. Creams over 60 per cent butterfat were obtained by separating 40 per cent cream. This procedure was found to give a product with the least amount of damaged fat globules. Skim milk from this operation is referred to as skim milk from reseparated cream. The butter and buttermilk were taken from commercial churnings.

All "lecithin" determinations were begun within two hours after the samples were obtained since it was found that the "lecithin" content of cream, skim milk and milk decreases rapidly with age, even when stored at 40° F. This observation is in agreement with the work of Cusick (3) Perlman, (14) and Rimpila and Palmer (15).

In experiments with washed creams, the volume of the original milk was measured (five gallons) and the resulting cream was diluted to this same volume with water at 100° F. in order to approximate the same fat percentage in the milk and maintain the same fat percentage in the cream.

"Lecithin" content of cream

The results of Perlman (13) and Jack and Dahle (10) show that as the fat content of cream increases to about 55 per cent there is a uniform increase in the phospholipid content. But above 60 per cent, they found that there was a decrease. Although they do not so state, it can be assumed that their creams were all separated from whole milk. In the results shown in Table 1 the creams over 60 per cent were separated from 35–40 per cent cream. This difference in method probably accounts for the difference in results since oiling off tests (11), microscopic examination, and general appearance of creams of high fat percentage obtained by reseparating 40 per cent cream indicated no churned or "free" fat.

Table 1 is composed of the results of several separation trials from several batches of milk extending from October to February. The milk to be separated was taken from a tank of about 10,000 pounds of milk after thorough mixing. The "lecithin" content of the milk was determined for each trial and varied from .035 per cent to .036 per cent.

TABLE 1

The "lecithin" content of cream of varying fat percentage

Fat (Mojonnier), per cent	"Lecithin" in product, per cent	"Lecithin" in extracted fat, per cent
14.14	.066	.463
16.84	.077	.459
18.89	.089	.469
21.54	.087	.406
21.90	.081	.367
22.44	.084	.374
32.00	.112	.349
36.23	.124	.344
38.45	137	.358
38.48	126	.327
38.98	.146	.374
39.10	.145	.372
39.51	.138	.349
40.23	.156	.387
40.87	.156	.382
41.00	.154	.376
41.29	.152	.369
41.78	.160	.383
41.81	.151	.359
43.69	.156	.358
43.98	.164	.374
48.11	.153	.318
50.63	.163	.323
53.34	.165	.309
54.30	.162	.300
55.81	.187	.335
56.89	.179	.314
68.43	.211	.308
72.26	.196	.271
75.21	.210	.279
75.79	.194	.256
76.15	.199	.261

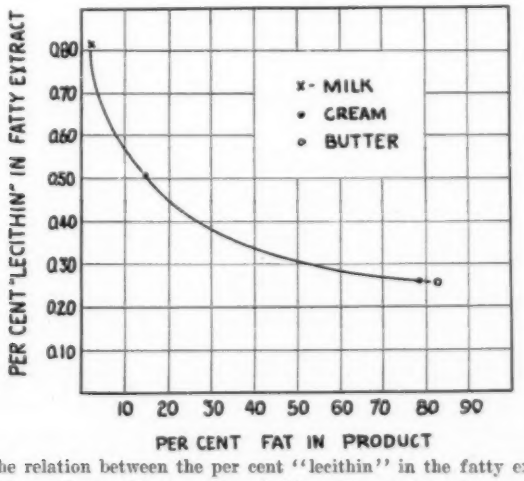

FIG. 1. The relation between the per cent "lecithin" in the fatty extract and the per cent fat in the product. (Buttermilk and skim milk not shown.)

Figure 1 shows the relation of the per cent "lecithin" in the cream (and other dairy products) to the per cent of fat in the cream, while Figure 2 represents the relation of the per cent "lecithin" in the fatty extract to the per cent fat in the cream (and other dairy products).

"Lecithin" content of other dairy products

The results shown in Table 2 for the "lecithin" content of other dairy products are in general agreement with the results of others. The per cent "lecithin" in the fatty extract is not constant but varies considerably among

TABLE 2

The "lecithin" content of dairy products

Product	Fat (Mojonnier), per cent	"Lecithin" in product, per cent	"Lecithin" in extracted fat, per cent
Skim milk	.075	.015	19.65
" "	.077	.018	24.05
" "	.066	.017	25.45
" "	.086	.017	19.79
" "	.080	.017	21.20
" "	.103	.017	16.55
" "	.077	.017	22.00
" "	.080	.016	19.97
" "	.089	.017	18.89
" "	.106	.016	14.78
" "	.096	.016	16.97
" "	.080	.018	21.90
" "	.090	.017	19.10
" "	.126	.018	14.52
" "	.076	.016	20.55
" "	.088	.016	18.42
Whole milk	5.01	.036	.720
" "	4.87	.035	.713
" "	5.50	.036	.655
" "	5.08	.036	.710
" "	5.10	.035	.691
" "	4.66	.035	.752
" "	4.71	.036	.765
" "	4.81	.035	.729
Sep. slime	1.12	.229	20.55
Buttermilk	.672	.114	16.93
"	.764	.128	16.81
"	.644	.126	19.55
Butter (sweet cream)	80.84	.216	.268
" " "	80.25	.209	.259
Butter (9 months in cold storage)	82.93	.165	.199
" " " " " "	82.69	.153	.184
Skim milk from 60–80% cream	.540	.093	17.25
" " " " "	.435	.084	19.36
" " " " "	.460	.080	17.40
" " " " "	1.378	.082	5.918
" " " " "	.196	.035	18.08
" " " " "	.192	.049	25.40

the various dairy products. It is apparently highest in skim milk, followed by buttermilk, milk, light cream, heavy cream, and butter.

The effect of washing on the "lecithin" content

The work of Rimpila and Palmer (15), Thurston, *et al.* (16), and Jack and Dahle (10) was repeated controlling as many factors as possible. Acidities were run to ascertain the amount of plasma present; oiling off tests (11) were run to determine the amount of free fat present after each washing. It was felt that as the oiling off increased, the amount of phospholipids originating from the fat might be increased, and this would give a false idea of the amount removed merely by washing. For this reason only 5 washings were employed.

Table 3 presents the decrease in the "lecithin" content of a cream containing 21.90 per cent fat and a cream containing 38.48 per cent fat. In addition is shown the observed decrease of "lecithin" due to washing and the calculated decrease.

TABLE 3

Effect of washing cream on the "lecithin" content

Sample		Fat, per cent	Acidity, per cent	Oiling off, units	"Lecithin" in product, per cent	Decrease in per cent "lecithin" due to washing	
						Observed	Calculated*
Trial I	Original	21.90	.125	.00	.081		
	1st washing	19.46	.040	.02	.062	.022	.020
	3rd "	21.49	.020	.06	.059		
	5th "	21.79	.015	.14	.059		
Trial II	Original	38.48	.105	.01	.126		
	1st washing	36.19	.030	.02	.112	.020	.021
	3rd "	40.93	.020	.17	.106		
	5th "	44.26	.015	.30	.107		

* Calculated by multiplying the per cent plasma in the product by the per cent "lecithin" in the plasma.

DISCUSSION

Altho Horrall (8) states that possibly "the lecithin is a separate constituent of milk and is not tied up with the fat," Bird, *et al.* (2), North and Sommer (12) and Jack and Dahle (9) conclude from their work that the phospholipid material is closely associated with the fat globule. Thurston, *et al.* (16) have shown that "agitation of milk caused a reduction in the lecithin content of the cream and a corresponding increase in the lecithin content of the skim milk." That this reaction is not reversible is shown by the work of Rimpila and Palmer (15) who studied the membrane of pure fat globules dispersed in skim milk and found that the normal fat globule membrane is not derived from milk plasma.

Nevertheless, the results presented here indicate that there are some phospholipids in the plasma of milk. Since the method of determining "lecithin" depends upon the determination of ether-alcohol soluble phosphorous, the method may give erroneous results. Indeed, Holwerda (7) states that there is a phosphoric ester found in milk which gives too high a value for phospholipid percentage. This indicates that possibly the plasma contains a substance extracted by the alcohol and ethers which contains phosphorus and which would vary with the amount of plasma in the dairy products. This substance, however, is not inorganic phosphates since Bird, *et al.* (1) and Wiese, Nair, and Fleming (17) state that these are not extracted. Trials have been made here which also substantiate this conclusion.

It seems, therefore, that the material extracted is organic in nature, yet that some of it is present in the plasma of milk. If simultaneous equations be set up as follows:

$$\left(\frac{12.2}{100}\right) x + \left(\frac{87.8}{100}\right) y = .060$$

$$\left(\frac{15.5}{100}\right) x + \left(\frac{84.5}{100}\right) y = .070$$

In which x = the per cent "lecithin" in the fat and y = the per cent "lecithin" in the plasma. The per cent "lecithin" in a cream with 12.2 per cent fat and 87.8 per cent plasma is .060; .070 is the per cent "lecithin" in a cream with 15.5 per cent fat and 84.5 per cent plasma. (This data was obtained from Figure 2.) Solving, x = 0.326% and y = 0.0230%.

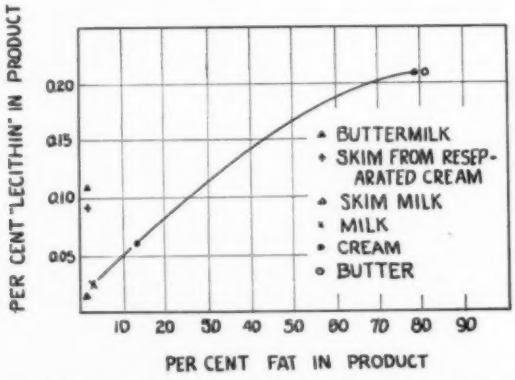

FIG. 2. The relation between the per cent "lecithin" in the product and the per cent fat in the product.

By solving many such equations and taking an average of the various x and y values, results are obtained which approximate the per cent phospholipid in the plasma and in the fat of creams of various fat percentages.

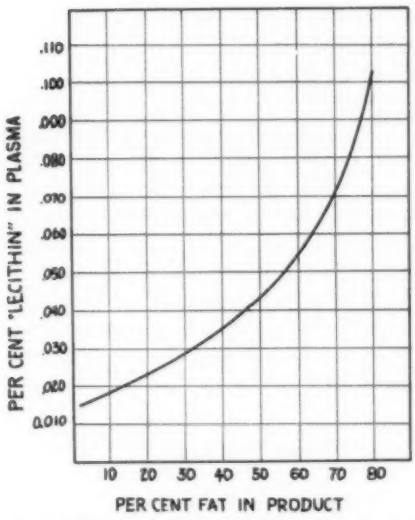

FIG. 3. The relation between the per cent "lecithin" in the plasma and the per cent fat in the product. (Not to be applied to buttermilk and skim milk from reseparated cream.)

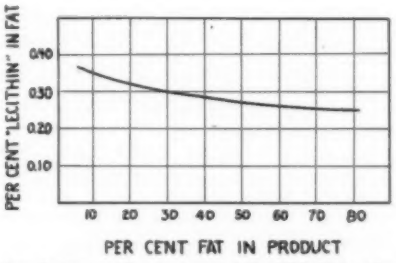

FIG. 4. The relation between the per cent "lecithin" in the fat and the per cent fat in the product.

These values are shown graphically in Figures 3 and 4 which may be further explained as follows:

In the milk products considered here a portion of the "lecithin" is associated with the fat and a portion is in the plasma phase. Figures 3 and 4 give the percentages of lecithin in the plasma and associated with the fat, respectively, as a function of the fat content of the product. The total "lecithin" content of the product can be calculated by dividing the percenage of fat in the product by 100 and multiplying by the corresponding percentage of "lecithin" (Figure 4) and adding to this value the result obtained by dividing the percentage of plasma in the product by 100 and multiplying by the corresponding percentage of "lecithin" in the plasma

(Figure 3). For example, the percentage of "lecithin" in 40 per cent cream would be calculated as follows:

$$\left(\frac{40}{100}\right)(0.29) + \left(\frac{60}{100}\right)(.035) = 0.137\%$$

(It must be pointed out that these figures may be found to apply only to milk from this section of the country and produced during the winter months.)

If the above supposition is true, then by washing cream of a given fat percentage one should be able to calculate the decrease in the per cent "lecithin" in the plasma from the total amount. This result is recorded in Table 3 and the calculated and observed decreases check closely.

The high "lecithin" content of buttermilk and skim milk from reseparated cream, may be explained by this method. According to Figure 3, the plasma of 75 per cent cream contains 0.09 per cent "lecithin." This plasma has the same composition as the skim milk resulting during the separation of 75 per cent cream. Consequently, it would have .09 per cent "lecithin" in its plasma. Since the plasma in such skim milk is about 99.9 per cent, there would be:

$$\left(\frac{99.9}{100}\right).09 + \left(\frac{.1}{100}\right).25 = .090\%$$

This agrees with the measured amount present. The "lecithin" content of buttermilk may be explained on the same basis.

It is possible that the statement of Thurston, *et al.* (16), previously referred to explains the increase in "lecithin" in the plasma as the fat in the product is increased, *i.e.*, there is a greater movement of "lecithin" from the fat to the plasma due to the increased mechanical agitation during the separation of creams of higher fat percentage.

SUMMARY AND CONCLUSIONS

1. The per cent "lecithin" in various dairy products was found to be as follows: skim milk, 0.015–0.018 per cent; raw whole milk, 0.035–0.036 per cent; skim milk from reseparated cream, 0.035–0.093 per cent; pasteurized sweet cream, 0.066–0.199 per cent; buttermilk, 0.114–0.126 per cent; butter, 0.153–0.212 per cent; separator slime, 0.229 per cent.

2. The "lecithin" in the products studied was found to be present partially in the plasma and partially associated with the fat.

3. The results obtained indicate that as the fat content of the product increases, there is an increase in the relative amount of "lecithin" in the plasma and a decrease in the relative amount associated with the fat, except in buttermilk and skim milk from reseparated cream.

4. The "lecithin" content of the fat and plasma in buttermilk and skim milk from reseparated cream is approximately the same as the "lecithin" content in the fat and plasma of the butter and 75–80 per cent cream from which they are derived. This accounts for the abnormally high "lecithin"

content of these two products compared to other products of a like fat content, *i.e.*, skim milk and whole milk.

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SOME FACTORS AFFECTING THE STABILITY OF CERTAIN MILK PROPERTIES. I. EFFECT OF SUCCULENT ROUGHAGES ON FLAVOR*

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Anderson (1, 2) seems to have been the first worker to report that there was an apparent relationship between carotene in the feed of the cow and the ability of the cow to produce a milk of good flavor. His work was followed by experiments (3, 4) at the New Jersey Agricultural Experiment Station in 1937 and reported in 1938 in which it was shown that there was a high positive correlation between yellow color and good flavor in milk. Hening and Dahlberg (5) however, concluded "that the feeding of mangels or beet pulp in no way prevented or increased the susceptibility of milk to the development of oxidized flavor." Beet pulp and mangels are low in carotene.

To study more completely the stability of flavor in milk, experiments were carried out during the winter months of 1937–1938 in which 4 purebred Holstein and 8 purebred Guernsey cows, carefully selected as to stage of lactation, were fed alternately on roughage rations of beet pulp, corn silage and molasses grass silage. Earlier work had indicated that beet pulp tends to deplete yellow color in milk even when fed for a comparatively short time (2–3 weeks) so on this basis it was selected as the control or basic roughage ration. The cows were matched as nearly as possible as to the color of their milk and were divided into two equal groups. The roughage feeding program was as follows for the two groups:

	Group I	*Group II*
Three weeks	Beet pulp	Beet pulp
One week	Transition	Transition
Three weeks	Grass silage	Corn silage
One week	Transition	Transition
Three weeks	Beet pulp	Beet pulp
One week	Transition	Transition
Three weeks	Corn silage	Grass silage
One week	Transition	Transition
Three weeks	Beet pulp	Beet pulp

In addition the cows received the usual grain ration and a rather poor quality field-cured hay throughout the experiment.

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TABLE 1

Average flavor scores

	Beet pulp		Grass silage		Beet pulp		Corn silage		Beet pulp	
	– Cu*	+ Cu**	– Cu	+ Cu	– Cu	+ Cu	– Cu	+ Cu	– Cu	+ Cu
	Group I									
Raw milk										
First day	20.63	20.42	22.33	21.42	21.03	20.47	20.93	20.54	20.78	19.78
Third day	19.98	18.65	21.63	20.63	21.04	19.67	20.25	19.38	19.00	17.92
Fifth day	17.56	15.44	20.56	19.11	17.50	15.69	17.06	16.48	17.56	14.63
Pasteurized milk										
Second day	20.81	20.03	22.47	21.11	21.29	20.29	20.84	19.56	20.43	17.49
Fifth day	18.86	16.02	20.71	18.33	19.58	14.61	18.65	14.73	17.70	14.36
	Group II									
	Beet pulp		Corn silage		Beet pulp		Grass silage		Beet pulp	
Raw milk										
First day	21.17	20.58	20.75	20.63	21.00	20.50	22.23	21.26	20.81	20.11
Third day	19.17	18.50	20.72	19.44	20.38	19.50	21.57	20.48	19.36	17.59
Fifth day	16.86	15.86	18.00	16.97	17.39	15.17	18.90	18.02	17.22	15.33
Pasteurized milk										
Second day	21.39	19.67	20.83	19.72	21.21	20.29	22.11	20.75	20.64	18.14
Fifth day	17.34	15.77	18.92	16.04	19.28	15.11	20.11	17.27	18.45	14.20

* – Cu—No copper.
** + Cu—Contains 1.3 parts copper per million parts milk.

Samples of milk from each cow were taken once each week for analysis. Half of each sample was stored raw and half was pasteurized before storage. To half of each of the raw and the pasteurized milks was added copper sulfate in amounts to give a concentration of 1.3 parts copper per million parts of milk. The raw milks were checked for flavor score and intensity of oxidized flavor on the first, third and fifth days. The pasteurized samples were checked on the second and fifth days.

In Table 1 are shown the average flavor scores of the milks for the two groups produced on the three different roughages. Only the scores of the milks obtained at the end of each roughage feeding period are used in arriving at the averages. It was felt that these values are more truly representative of each feed than if the scores throughout each feeding period (three weeks) had been used since there is an apparent carry-over effect from previous feeds for several days. From the data obtained it is even doubtful that three weeks is sufficient time to reach maximum or minimum effects from the different feeds.

The data presented in Table 1 are summarized in Table 2. They definitely show that the milks produced on molasses grass silage were of better initial flavor, held their good flavor in storage better, and withstood the destructive effects of soluble copper better than those milks produced on either corn silage or beet pulp. This was not only indicated by the average score but is supported by the fact that the milk of every cow without exception showed improvement in flavor over either corn silage or beet pulp when the roughage ration was mainly grass silage. Not much difference in flavor quality could be noticed between milks produced on corn silage and those on beet pulp. The data, however, indicate a slight advantage for corn silage over beet pulp in the way the milks kept in storage or withstood copper contamination.

TABLE 2

Summary of average flavor scores

	Beet pulp		Corn silage		Grass silage	
	− Cu	+ Cu	− Cu	+ Cu	− Cu	+ Cu
Raw milk						
First day	20.90	20.31	20.84	20.59	22.28	21.34
Third day	19.82	18.64	20.49	19.41	21.60	20.56
Fifth day	17.35	15.35	17.53	16.73	19.73	18.57
Pasteurized milk						
Second day	20.96	19.32	20.84	19.64	22.29	20.93
Firth day	18.54	15.01	18.79	15.39	20.41	17.80

The color of the milks was measured by the "lactochrometer," an instrument developed by the New Jersey Station for the American Guernsey Cattle Club. The color values, expressed as "lactochrometer units," for the fresh raw milks analyzed on the day the samples were obtained from the cows are presented in Table 3 and summarized in Table 4. Again only the samples

obtained at the end of each respective roughage feeding period were used for obtaining these values.

TABLE 3

Average color values

Group I				
Beet pulp 4.28	Grass silage 5.09	Beet pulp 4.43	Corn silage 4.59	Beet pulp 4.03
Group II				
Beet pulp 4.48	Corn silage 4.54	Beet pulp 4.01	Grass silage 5.43	Beet pulp 4.08

TABLE 4

Summary of average color values

Roughage	Color value
Beet pulp	4.22
Corn silage	4.57
Grass silage	5.26

The relation between high yellow color and good flavor, as found in the 1937 studies, is completely substantiated by these studies as shown by the data presented in Table 5 and the correlation coefficients listed in Table 6.

TABLE 5

Ranking of color and flavor by individual cows

Cow No.	Breed	Color (Fresh raw milk)		Flavor (Fresh raw milk)	
		Units	Rank	Score	Rank
465	Guernsey	5.89	1	21.47	2
247	"	5.46	2	21.422	3
164	"	5.36	3	21.51	1
422	"	5.33	4	21.34	6
179	"	5.07	5	21.35	5
475	"	5.06	6	20.92	10
471	"	5.05	7	21.419	4
431	"	4.81	8	21.14	7
92	Holstein	4.11	9	21.086	9
129	"	3.72	10	20.71	11
226	"	2.90	11	21.087	8
284	"	2.23	12	20.62	12

The rankings of the cows for flavor (Table 5) agree fairly well with those of color with the exception of No. 475. This cow had mastitis during the latter part of the experiment which brought her average flavor score down below what might have been expected under more favorable circumstances. Cow No. 422 also produced a salty milk toward the end of the experiment which lowered the flavor score somewhat.

More significant, perhaps, than the data presented in Table 5 are the correlation coefficients (product moment method) shown in Table 6. Coeffi-

TABLE 6

Correlation coefficients; color vs. flavor

	Samples at end of period		All samples	
	r	S.D.*	r	S.D.*
Raw milk without copper				
Color vs. flavor (1st day)	+.5287 ± .0627**	0.7180 ± .0442**	+.4691 ± .0359**	0.6833 ± .0222**
" " " (3rd ")	+.5690 ± .0589	1.0214 ± .0720	+.4928 ± .0348	1.2019 ± .0391
" " " (5th ")	+.7747 ± .0348	2.2013 ± .1355	+.5253 ± .0333	1.8693 ± .0608
Raw milk with copper				
Color vs. flavor (1st day)	+.3848 ± .0742	0.6733 ± .0415	+.3806 ± .0393	0.6225 ± .0202
" " " (3rd ")	+.6286 ± .0583	1.5880 ± .0978	+.5661 ± .0313	1.5003 ± .0488
" " " (5th ")	+.6795 ± .0469	1.9857 ± .1223	+.5634 ± .0314	1.7530 ± .0570
Pasteurized milk without copper				
Color vs. flavor (2nd day)	+.5217 ± .0634	0.7772 ± .0479	+.5294 ± .0332	0.7729 ± .0252
" " " (5th ")	+.6600 ± .0491	1.4331 ± .0882	+.5865 ± .0302	1.3040 ± .0425
Pasteurized milk with copper				
Color vs. flavor (2nd day)	+.4153 ± .0721	1.4383 ± .0886	+.3735 ± .0398	1.1514 ± .0375
" " " (5th ")	+.5713 ± .0586	1.8601 ± .1145	+.5392 ± .0327	1.6349 ± .0533

Standard deviation of color (samples at end of period) = 1.1692 ± .0720.
Standard deviation of color (all samples) = 1.1261 ± .0367.
* Standard deviation of flavor.
** Probable error.

TABLE 7

Average loss of flavor

	Without copper				With copper			
	Third day*		Fifth day		Third day*		Fifth day	
	Points	Per cent	Points	Per cent	Points	Per cent	Points	Per cent
Raw milk								
All samples	1.02	4.87	2.91	13.66	2.04	9.64	4.33	20.49
Guernsey samples	0.82	3.88	2.41	11.09	1.80	8.45	4.06	19.10
Holstein samples	1.42	6.84	3.91	18.81	2.51	12.02	4.85	23.28
Beet pulp samples	0.99	4.72	2.91	13.90	2.30	10.95	4.83	23.01
Corn silage samples	0.85	4.10	3.00	14.44	1.61	7.75	3.85	18.45
Grass silage samples	1.14	5.20	2.80	12.75	1.92	8.74	3.75	17.04
Pasteurized milk								
All samples	+0.02	+0.10	2.16	10.22	1.15	5.41	5.21	24.51
Guernsey samples	+0.04	+0.22	1.89	8.87	1.18	5.51	5.05	23.55
Holstein samples	0.02	0.12	2.70	12.93	1.10	5.23	5.53	26.45
Beet pulp samples	+0.03	+0.18	2.20	10.47	1.14	5.35	5.40	25.76
Corn silage samples	0.06	0.31	2.25	10.78	0.96	4.61	5.02	23.92
Grass silage samples	0.06	0.25	2.16	9.83	1.14	5.18	4.65	21.15

* Second day for pasteurized milk.

cients were calculated on the basis of only those samples taken at the end of each roughage feeding period and also on the basis of all samples taken during the experiment.

It will be observed that the significance of the correlation between color and flavor increases as the storage period increases. This is true of both raw and pasteurized milks and also of those samples containing copper. It will be observed also that the correlation is relatively insignificant when copper is first added to the milk but that the significance greatly increases as the milk ages. This probably is because the metallic taste at first imparted to the milk by the copper tends to bring the flavor of all samples to a fairly common level. Later on with the onset of oxidation and the development of oxidized flavors the correlation becomes more significant.

In Table 7 are shown the average losses of flavor of raw and pasteurized milks without and with added copper. The per cent of loss of each case is calculated on the basis of the score of the raw fresh milk as 100 per cent. The slight gains in flavor for second-day pasteurized milk over first-day raw milk are due to improvement in flavor by pasteurization which frequently happened when the raw milk exhibited a feedy flavor. Both raw and pasteurized milks produced on grass silage showed an actual as well as a percentage loss less than those milks produced on either beet pulp or corn silage.

The high negative correlation coefficients presented in Table 8 definitely

TABLE 8

Correlation coefficients, color vs. loss of flavor

	r	S.D.*
Raw milk		
Without copper		
Color vs. loss of flavor (third day)	$-.8902 \pm .0404$**	$1.6988 \pm .2339$**
Color vs. loss of flavor (fifth day)	$-.9062 \pm .0348$	$3.8435 \pm .5292$
With copper		
Color vs. loss of flavor (third day)	$-.8176 \pm .0645$	$2.7953 \pm .3849$
Color vs. loss of flavor (fifth day)	$-.7659 \pm .0805$	$3.4747 \pm .4784$
Pasteurized milk		
Without copper		
Color vs. loss of flavor (second day)	$-.6395 \pm .1151$	$0.7651 \pm .1053$
Color vs. loss of flavor (fifth day)	$-.9115 \pm .0329$	$2.2418 \pm .3087$
With copper		
Color vs. loss of flavor (second day)	$-.3108 \pm .1759$	$1.6834 \pm .2318$
Color vs. loss of flavor (fifth day)	$-.5464 \pm .1366$	$3.5631 \pm .4906$

Standard deviation of color = $1.0689 \pm .1472$.
* Standard deviation of flavor score.
** Probable error.

show that milks of high yellow color tend to lose less of their flavor in storage than do milks of lower color. This seems to indicate that carotene, or some factor associated with carotene, when present in sufficient quantity has a

stabilizing effect on milk flavor. The low coefficient of second-day pasteurized milk with copper is probably due to the fact that the copper has tended to bring all the milks to a fairly common flavor level, as explained above, but has not had time to produce a high degree of oxidized flavor.

The degree or intensity of oxidized flavor in a milk induced by the addition of soluble copper should be a fairly satisfactory index of the efficiency of a feed in preventing or retarding oxidation if our theory that certain feeds contain inhibitors or antioxidants is correct. The data in Table 9 do show a

TABLE 9

*Distribution and intensity of oxidized flavor**

	Raw milk		Pasteurized milk	
	Third day	Fifth day	Second day	Fifth day
Samples at end of period				
All samples	0.91	2.25	0.73	3.08
Beet pulp samples	1.25	2.86	0.95	3.39
Corn silage samples	0.67	1.58	0.58	3.42
Grass silage samples	0.17	0.92	0.25	1.83
All samples				
All samples	0.98	2.03	0.63	2.88
Beet pulp samples	1.30	2.71	0.79	3.16
Corn silage samples	0.67	1.47	0.47	2.86
Grass silage samples	0.47	1.00	0.28	2.03

* All samples contained added copper.

wide variation in the intensity of the flavor when milk is produced on roughages of different carotene content. The oxidized flavor scores presented in this table are obtained by assigning the numbers, 0, 1, 2, 3, 4, 5, to represent the different degrees of oxidation. A number 1 represents a barely perceptible oxidized flavor while a number 5 indicates a milk of such high intensity of flavor that it is practically unsalable. Here again molasses grass silage appears quite superior to either corn silage or beet pulp for producing a milk which will resist the development of oxidized flavors. Although not shown in the data presented in this paper there was a considerable number of cases where, without the addition of copper, oxidized flavor appeared in the beet pulp or corn silage milk, but not in a single instance did this occur in the grass silage milk. In fact where oxidized flavor appeared previous to the feeding of grass silage, the condition cleared up within a short time after grass silage feeding was begun.

An analysis of the hydrolytic rancid flavor which developed in the raw milks used in this study is presented in Table 10. The same numerical values were used for the intensities of the rancid flavor as were employed for the oxidized flavor. These data do not seem quite so significant as in the case of the oxidized flavor, especially if the data on all samples throughout each feed-

ing period are taken. But if only the samples at the end of each feeding period are used, then it appears that the feeding of grass silage had some effect in preventing the development of an intense rancid flavor. The lack of significance in the former case and the occurrence of significance in the latter suggests that a longer feeding period on grass silage might help to greatly inhibit the development of rancid flavor.

TABLE 10

Distribution and intensity of rancid flavor

	Samples at end of period		All samples	
	Third day	Fifth day	Third day	Fifth day
All samples	0.90	1.83	0.91	1.59
Beet pulp samples	0.95	1.94	0.91	1.59
Corn silage samples	0.92	2.00	0.97	1.94
Grass silage samples	0.42	1.33	0.81	1.53

When the original scores of the fresh raw milks were correlated against the corresponding per cents loss of flavor during storage, high negative correlation coefficients were obtained. This indicates that milks of high original flavor score will retain their flavor in storage better than milks with beginning low flavor scores. The correlation coefficients are shown in Table 11.

TABLE 11

Correlation coefficients; original flavor score vs. percentage loss

	r	S.D.*
Raw milk without copper		
Third day	$-.8300 \pm .0606$**	$1.6988 \pm .2339$**
Fifth day	$-.7577 \pm .0829$	$3.8435 \pm .5292$
Raw milk with copper		
Third day	$-.7981 \pm .0707$	$2.7953 \pm .3849$
Fifth day	$-.8317 \pm .0600$	$3.4747 \pm .4784$
Pasteurized milk without copper		
Second day	$-.6762 \pm .1057$	$0.7651 \pm .1053$
Fifth day	$-.8352 \pm .0589$	$2.2418 \pm .3087$
Pasteurized milk with copper		
Second day	$-.3641 \pm .1689$	$1.6834 \pm .2318$
Fifth day	$-.6202 \pm .1198$	$3.5631 \pm .4906$

Standard deviation of original flavor score = $0.2862 \pm .0394$.

* S.D. = standard deviation of loss of flavor score.

** Probable error.

The results of this study tend to show on the whole that the feeding of molasses grass silage helps to stabilize the flavor of milk thus produced. This seems to be especially true with regard to the development of oxidized flavors. Molasses grass silage is considerably higher in carotene than is corn silage or beet pulp as shown by chemical analysis and evidenced by the greater amount of yellow color in the milk and the large amount of yellow secretion in the skin of the cows. The yellow skin secretion was especially noticeable in the

Holsteins which during the winter months, usually are almost entirely lacking in such secretion.

Shrewsbury and Kraybill (6) have shown that some substance associated with carotene in butterfat exhibits antioxidative properties toward the oxidation of the carotene. In studies on the keeping quality of butter (7) observations were made that the end of the induction period of accelerated oxidation of pure butterfat was invariably accompanied by rapid and almost complete bleaching of the yellow color. Immediately thereafter rapid absorption of oxygen by the butterfat began. This phenomenon may either mean that the carotene itself was acting as antioxidant toward the fat and that oxidation of the fat could not begin until all the carotene was oxidized or it may mean that some other unidentified natural antioxidant is normally present and the bleaching of the carotene is merely evidence that the activity of this natural antioxidant has been overcome and is the first step in the progressive oxidation of the butterfat proper.

Although the results of this study do not definitely prove that the carotene in the feed or in the milk is the true causative antioxidant factor, they do indicate definitely that it is an associative one. If the stabilizing influence comes into play only after the milk is drawn from the cow, it is possible that the substance postulated by Shrewsbury and Kraybill is the true causative factor. If, on the other hand, the stabilizing influence begins in the milk as it is being synthesized in the mammary tissue, as seems quite likely, then the carotene (or vitamin A) may be the true factor. This would be especially true if the carotene (or vitamin A) served to keep the mammary tissue in a healthy condition and functioning properly.

SUMMARY

The results of these studies indicate that:

The feeding of molasses grass silage to milking cows has the advantage over either beet pulp or corn silage in that it produces milk which:

(a) Has a superior initial flavor.

(b) Has a more stable flavor in storage.

(c) Is more stable toward the catalytic effects of added soluble copper.

The feeding of grass silage prevents the development of oxidized flavor in milk when it is not contaminated with soluble metal and greatly retards the development and lessens the intensity of the flavor when soluble copper is added.

Accelerating the oxidation reaction by adding soluble copper to milk seems to be a satisfactory means of demonstrating, more or less quantitatively, the relative stability of flavor of different milks.

The feeding of molasses grass silage seems to retard the development of hydrolytic rancidity in milk. The results presented in this article are not as conclusive as those on oxidation and the subject needs further study.

There is a significant positive correlation between the yellow color and the flavor of freshly drawn milk from individual cows.

A very significant negative correlation exists between the yellow color of the fresh milk and the loss of flavor in this milk during storage.

Milks of extra good flavor when fresh retain their good flavor in storage better than corresponding milks of poorer flavor quality.

The stabilizing effect on flavor of grass silage seems to be due, in part at least, to the comparatively high carotene content of this type of feed.

The feeding of properly ensiled green grass crops appears to be a highly satisfactory method of producing a milk of high flavor stability during winter months in northern climes.

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RAPID PHOTOELECTRIC DETERMINATION OF CAROTENOID IN MILK FAT

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INTRODUCTION

The importance of carotene as a precursor of vitamin A and as a yellow pigment has led to many studies in recent years on the carotene content of milk fat. There is need for a reliable method for determining carotene which is rapid enough so that a large number of samples can be studied and which does not require extremely elaborate and expensive equipment. We have devised a method by which the carotene or more precisely total carotenoid content can be determined directly in a sample of melted milk fat with the use of a photoelectric cell and suitable glass filters. No weighings or dilutions are necessary and only a few seconds are required for a determination after the melted fat has been prepared from cream. Three cubic centimeters of milk fat are needed for an analysis.

Several authors (1, 5, 8, 9) have encountered difficulties in the use of a simple colorimetric method for determining carotenoid concentrations. For example, the fields in the colorimeter are difficult to match since the color varies with concentration, temperature, and with the solvent. Also when read visually against dichromate, the depth of color is not proportional to concentration, and is three times as intense when carotene is dissolved in melted butter as when dissolved in petroleum ether. Some of these difficulties are avoided when a photoelectric colorimeter is used. Spectrophotometers of many modifications have been employed (1, 2, 3, 4, 8, 9). These instruments are expensive and are not available in most laboratories where problems on the color of milk fat are being studied.

APPARATUS

Design of photoelectric colorimeter

The photoelectric colorimeter we have used can be constructed very simply. A 30 candlepower automobile headlight bulb is used as a source of light in connection with a storage battery. It is important *not* to plug this light into a socket, but to solder wires directly to the base. This prevents light fluctuations due to heating of the contacts. Between the lamp and the absorption cells are placed two condensing lenses and an iris diaphragm by means of which the intensity of the light is controlled. A diaphragm from a microscope condenser is satisfactory for this use. The diaphragm is placed in a region of parallel light rays. The condensers are biologist's magnifiers

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which are sold in most student supply houses. They have a focal length of about one inch. They are so adjusted that the filament is at the focal point of one and the center of the absorption cell at the focal point of the other. The glass filters and the diaphragm are placed between the lenses. Adjacent to the absorption cell and between the absorption cell and the light is a slit about 4 mm. wide to cut out stray light. Behind the absorption cell is the photoelectric cell of the blocking layer type, which is connected to a microammeter with a full scale of 15 microamperes and an internal resistance of 150 ohms. Molded Corning glass filters two inches square were used. For carotenoid in milk fat, Nos. 585 and 428 were found to be the most suitable. Figure 1 is

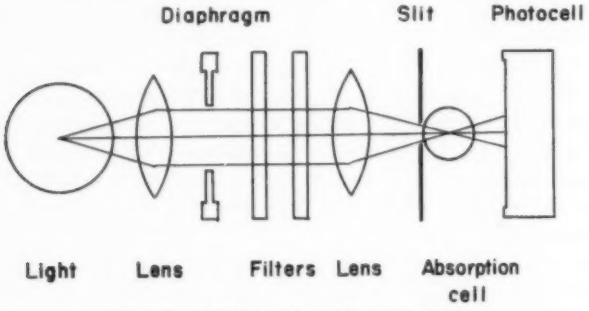

FIG. 1. Optical system of colorimeter.

a diagrammatic sketch of the apparatus.

The chief feature of our instrument which makes it convenient for work with milk fat is the type of absorption cells used. These cells are small test tubes, 10 cm. long, made from precision glass tubing with an inner diameter of 10.00 mm. ± .01 mm.* The tubing is not perfectly clear, but it is uniform. The imperfections have no significant effect on the microammeter readings, as can be readily demonstrated by rotating the tubes while obtaining the readings. The tubes have many advantages over the ordinary plane absorption cells with respect to ease of cleaning, cost of replacement, small quantities of liquid required, and rapidity of determinations. Grease never creeps on to the outside surface and the tubes can be tightly stoppered for use with volatile liquids. By focusing on the center of the cylindrical tubes more intense light is obtained than in the case of the plane cells which intercept parallel light. Ordinary test tubes can be used, but their diameters must be measured and for each determination the absorption coefficient must be calculated and corrected to 1.0 cm. With the precision tubes a single reading is recorded and the concentration of unknown obtained simply by reference to a table with no calculation being required.

* This tubing, K. P. G., Duran glass, can be obtained from the Fish-Schurmann Corporation, New York City.

Calibration of the photoelectric colorimeter

The light absorption of pure carotene was determined in the apparatus by testing three samples of carotene dissolved in petroleum ether. One sample from Hoffmann La Roche was labeled 75 per cent beta carotene and 25 per cent alpha. Another from the S.M.A. Corporation was labeled carotene, and a third from the S.M.A. Corporation was labeled beta carotene. All these samples showed essentially the same light absorption (maximum deviation ± 5.3 per cent from the mean). The sample yielding the highest of these three values was assumed to be the purest because any likely impurities or decomposition would result in weaker light absorption.

Change in solvent produces a marked change in the color of carotene solutions. Thus the color in carbon bisulfide is much redder but the absorption is less intense than in petroleum ether. The filter combination selected for routine determinations of carotenoid in butter was the most insensitive to change in solvent or temperature.

Ordinarily those filters are selected for colorimetric work whose transmission band corresponds most closely to the maximum in the absorption band of the solution. The filter combination, yielding the highest value of absorption coefficient, would be most nearly ideal, because it would permit determinations in the most dilute solutions. However, in the case of carotenoid in milk fat it is advantageous to use a filter combination which yields a lower value for absorption coefficient. This is due to the high concentration of carotenoid in some samples which absorbs the light so nearly completely with "ideal" filters that accurate readings can not be obtained. With a less sensitive filter combination (such as 585 and 428) all the milk fat samples encountered by us absorbed the light incompletely and thus could be measured directly without dilution.

Another requirement for a filter combination is that the absorption coefficient of the substance to be tested should increase rapidly with concentration over the whole range. It is not necessary that there be direct proportionality with concentration. In fact direct proportionality is difficult to obtain without the use of monochromatic light. As a matter of fact deflections of the microammeter are not exactly proportional to light intensity unless a correction is made for the fixed resistance of the microammeter and the variable internal resistance of the photronic cell. By using a microammeter of low resistance this latter effect can be made very small. A method has been devised for eliminating this deviation (10) but simplicity is sacrificed. It was considered simplest to plot an empirical curve for a standard carotene solution with the actual readings depending on the characteristics of the filters, photocell, microammeter and light. The absorption coefficients reported here are more precisely the logarithms of the ratio of two microammeter readings rather than of two light intensities.

A calibration curve for the change in absorption coefficient with carotene

concentration in cotton seed oil has been determined and is shown in Figure 2. Cotton seed oil was used as a solvent for the calibration curve instead of

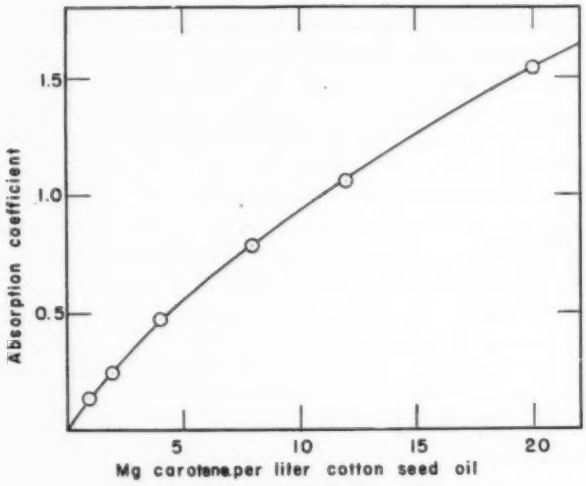

FIG. 2. Light absorption by carotene.

using butter itself as a solvent for the reason that corrections could be accurately made for the light absorption of the solvent alone. Small values of absorption coefficient for the solvent can be subtracted directly from the values for a solution containing added carotene to obtain the absorption coefficient of carotene. But this correction cannot be made by simple subtraction in solutions of high absorption as in the case of butter where there is no longer a linear relation between absorption and concentration.

After the calibration curve is once obtained, none of the parts of the instrument can be changed without recalibration. It is particularly important to note that the glass filters and the photocells can not be exactly duplicated. For this reason the calibration curve shown in Figure 2 is correct only for the particular instrument in which it was determined. Moreover the positions of the light and photocell in the instrument must not be changed because the same region of the photocell surface must be illuminated in all determinations. It is very convenient to check the adjustment of the instrument each time that it is used by testing a standard solution of potassium bichromate containing 0.2024 grams c.p. potassium chromate in 1 liter of N/10 sulfuric acid. In our instrument this solution absorbs half the light* thus having an absorption coefficient of 0.301 with filters 585 and 428.

* We are indebted to Dr. Hugo Doob for the preparation of this solution and tests on its stability as well as for the observation that azobenzene could not be used because of its light sensitivity.

As a further rough check on the purity of the carotene preparations, the apparatus was calibrated with azobenzene. It was found that a solution of 14.5 mg. azobenzene in 100 cc. of 95 per cent alcohol corresponded to a solution of 2.28 mg. carotene per liter. This value is in agreement with the 2.35 mg. found by Kuhn and Brockmann (5) for both alpha and beta carotene, using a cobalt glass filter. Because of its light sensitivity azobenzene is not as satisfactory a standard as potassium chromate for use in a photoelectric colorimeter.

TABLE 1

Effect of solvent on the light absorption of carotene (4 mg. per liter, 1 cm. thickness)

Solvent	$\log \frac{I_o}{I}$ Filter 585 + 428	$\log \frac{I_o}{I}$ Filter 556 + 038
Petroleum ether	.531	.735
Ethyl ether	.516	.764
Methyl alcohol	.513	.768
Abs. ethyl alcohol	.499	.792
Cottonseed oil	.470	.756
Melted butter 75°	.47	
Benzol	.391	.765
Chloroform	.355	.452
Carbon bisulfide	.306	.596

The observed absorption coefficient for our standard carotene in petroleum ether, with filters 556 and 038 was $\log_{10} \frac{I_o}{I} = 0.198$ for solutions of 1 cm. depth and containing 1 mg. per liter. Kuhn (6) gives a value of the molar extinction coefficient of 36×10^4 for beta carotene in hexane and 33×10^4 for alpha. Miller, MacKinney and Zscheile (7) found 32.6×10^4 for both alpha and beta carotene in 20 per cent ether–80 per cent ethanol. These are maximum values for strictly monochromatic light. Judging from the shape of the absorption curve it is probable that where filters are used the observed values should be somewhat lower than 30×10^4. Our value of absorption coefficient can be transformed into molar extinction coefficient by multiplying by $1000 \times 536 \times 2.30$. The result, 24.5×10^4 is close enough to the expected value to serve as an additional check on the method.

PROCEDURE

The actual determination of carotenoid in milk fat is made as follows: The fat is prepared by churning about 100 ml. portions of cream by shaking, then washing with cold water, melting and centrifuging. A 3 to 5 ml. sample is placed in the precision tube and warmed to about 75° C. to produce a clear solution. Another precision tube containing water is inserted in the colorimeter and the diaphragm adjusted until the microammeter reading is 15.0.

The water tube is removed and the tube containing fat is inserted and the reading recorded. The logarithm of the ratio of the reading for water to the reading for melted fat is the absorption coefficient of the melted fat. The carotenoid content can be obtained from the absorption coefficient by reference to a calibration curve as shown in Figure 2. It is not necessary to calculate the absorption coefficient for each determination. A table can be prepared giving carotenoid content in mg. per liter of melted fat from the single readings made on the melted fat if the light is so adjusted that the readings for the water tube are always exactly 15.0.

There are a number of sources of error which limit the accuracy of the method. The most obvious is the purity of the carotene sample used for standardization. Furthermore there is a possibility of oxidation of the carotenoid during the churning and warming of the sample. Also since the color of carotenoids is so sensitive to temperature and change in solvent it is reasonable to expect that the same amount of carotene would produce a slightly different color in different milk fat samples. Actual readings on the instrument deviate from the mean on an average of $\pm$ 0.7 per cent. A great deal of further work will be needed to establish the limits of accuracy of the method. The analytical uncertainties are no greater than in the more involved methods of analysis described in the literature. The chief requirement for a method for studying variations in milk fat is rapidity. Since individual samples vary from 1.5 to 21.5 mg. carotenoid per liter of melted fat, an adequate description of the carotenoid content of milk fat samples can best be given in the form of a distribution curve for which a large number of analyses are required.

SUMMARY

Churn 100 ml. samples of cream by shaking; wash the fat with cold water, melt, and centrifuge clear. Transfer 3 ml. to a precision tube absorption cell and warm to about 75° C. to produce a clear solution. Determine the light absorption for blue light in a photoelectric colorimeter and calculate the carotenoid content in mg. per liter of melted fat with the aid of a calibration curve obtained with pure carotene dissolved in cotton seed oil.

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THE CAROTENOID CONTENT OF MILK FAT

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A study of the carotenoid content of milk fat from New York State cows has been made during the year 1936–37 to get additional information on content and the extent of variation with individual cows, seasons, and breeds. Carotenoid content in the fat from 551 milk samples was determined by photoelectric measurement of light absorption in samples of melted fat using Corning glass filters 585 and 428 by the method described in detail in a preceding publication (9). The results of our analyses are shown in Tables 1 and 2, and Figures 1 and 2.

TABLE 1

Carotenoid content of milk fat present in samples of commercial bottled milk collected in various cities in New York State

Date	Number of samples	Carotenoid content mg./liter of fat	
		Range	Average
July 1, 1936	75	4.85–24.6	10.15
Feb. 10, 1937	173	1.54– 7.26	3.77
March 29, 1937	86	1.51– 7.19	3.38
May 29, 1937	79	3.52–21.5	9.38

TABLE 2

Carotenoid content of the milk from individual cows of the Cornell herd

Breed	Barn-silage feed April 7, 1937			June 8, 1937 Summer-pasture feed		
	Number of samples	Carotenoid content mg./liter of fat		Number of samples	Carotenoid content mg./liter of fat	
		Range	Average		Range	Average
Guernsey	13	4.68–12.0	8.50	13	10.4 –20.8	16.4
Jersey	25	4.15–11.5	5.87	21	6.55–14.2	10.5
Brown Swiss	3	5.14– 6.29	5.65	3	3.95–13.6	7.96
Ayrshire	11	1.93– 9.59	4.27	8	5.77– 9.85	6.58
Holstein	20	1.45– 9.42	3.49	17	2.72–10.6	5.78
Herd	72	1.45–12.0	5.42	62	2.72–20.8	9.95

Expressing the carotenoid concentration in mg. per liter of melted fat* at 75° C. we have observed variations from 1.5 mg. per liter to 24.6 mg. For

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* The unit of mg. per liter has been selected because of the colorimetric method of determination which depends directly on concentrations, and eliminates the necessity of measuring or calculating densities. The method yields the value for total carotenoid which in milk fat is about 94 per cent beta carotene and 6 per cent xanthophyll[3].

commercial milks the average seasonal variation was about 300 per cent, *i.e.* from 3.4 mg. per liter on winter barn feed to 10.2 on summer pasture feed.

The seasonal variation in the Cornell herd was not so great, the carotenoid values holding up better in the winter. The breed variation was considerably greater than the seasonal variation in the Cornell herd. For example, Holstein fat in July contained 5.78 mg. carotene per liter as against 16.4 mg. per liter for Guernsey. We have observed other instances of a similar nature where studies on a single herd yielded results different from those with commercial milks. For example, the seasonal variation in riboflavin is less in the Cornell herd than in commercial market milk samples (10).

The curves in Figure 1 are intended to show the uniformity in milk

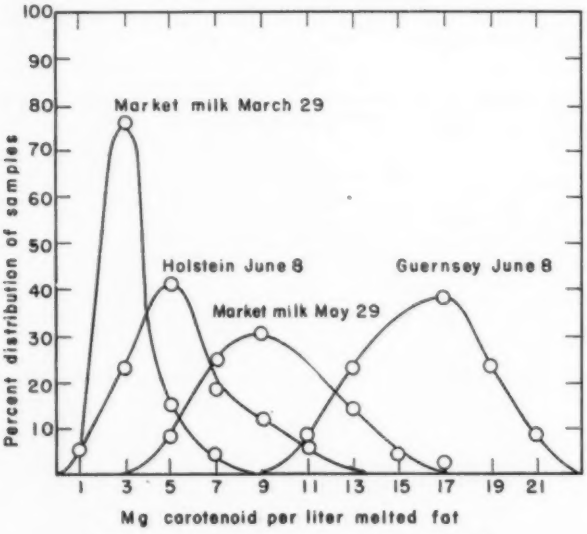

FIG. 1. Distribution of carotenoid in milk fat.

samples. Winter samples were very much more uniform than summer samples. The difference between Guernsey and Holstein was so pronounced that there was practically no overlapping of the curves.

A further study was made on the individual and seasonal variation in carotenoid content of milk fat in a group of 6 cows during the 3 months of May, June and July, 1938. The group contained 3 Guernsey and 3 Holstein cows and were being fed molasses grass silage or, in some cases, phosphoric acid grass silage for the first 5 days. After going on pasture there was a delay of about 1 day before the carotenoid content of the milk fat began to increase. Approximately 2 weeks were required before the maximum value was reached.

During June and July there was no further increase in carotenoid content. The results are shown graphically in Figure 2.

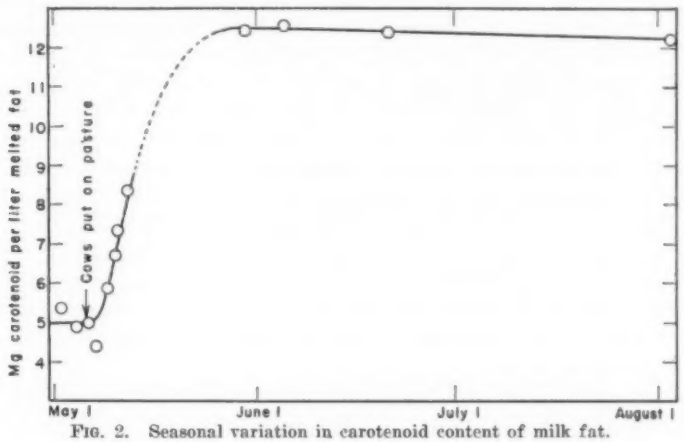

FIG. 2. Seasonal variation in carotenoid content of milk fat.

Our results are consistent with most of the reports in the literature. Gillam (7) studied 70 cows in England and found an average of 0.327 mg. carotene per 100 grams dry butter (2.88 mg. per liter melted butter at 75° C.). His values of 0.15 mg. carotene per 100 grams dry butter for winter feed and 0.6 mg. for moderate grass feed are about one-half as large as the corresponding values for New York State cows. Knudsen and Nielson (11) studied seasonal variations in the color of butter fat, observing the lowest color in April and maximum color in May-June. Baumann and Steenbock (1) report samples of March butter of 2.2 micrograms per gram dry butter and July samples of 8.6 micrograms. These samples are very similar to many analyzed by us. Baumann and Steenbock (2) found among breeds that the Guernsey had the highest carotene content in the fat, that the Holstein and Ayrshire were lowest, and that the Jersey and Brown Swiss were intermediate. We have confirmed this and found, for the cows examined, that Ayrshire milk fat has more carotene than Holstein, and Jersey more than Brown Swiss. The results of Wilbur, Hilton and Hauge (14) are much higher than any other values in the literature, namely, 1.8 mg. per 100 grams fat for Ayrshire and 3.6 to 4.0 for Guernsey. Their determinations were made with a Lovibond tintometer and no actual experimental data were reported.

In going from breed to breed there is no direct relationship between carotenoid content of milk fat and vitamin A potency. A small fraction of the carotenoid pigment is inactive xanthophyll and a large part of the vitamin A potency is due to the colorless vitamin A. Wilbur, Hilton and Hauge (14)

found the vitamin A in both Ayrshire and Guernsey milk fat to be practically the same by biological tests. Baumann and Steenbock (2) also reported that breed differences in milk fat with respect to vitamin A activity are small (spectrographic method). Thus on the same feed vitamin A per se is lower in the milk fat from those breeds which are high in carotene. In commercial (mainly Holstein) milk carotene accounts for only 15 per cent of the vitamin A potency (1) but for most of the activity in Guernsey milk. Gillam and others (3, 8) have studied both vitamin A and carotene by the spectrographic method in milk fat from 8 cows of 4 English breeds and they have found large individual variations, but no significant differences between breeds. Davis and Hathaway have observed that whole milk from different breeds is uniform in vitamin A potency (6). Because of the small number of samples investigated in these studies there is some uncertainty in the actual values. Obviously some of the results are contradictory because if there is no difference between breeds with respect to whole milk there must be a difference with respect to milk fat.

As far as individual variations in the same breed are concerned, Treichler, Grimes and Fraps (13) find that highly colored milk fats are apt to be high in vitamin A potency, but not necessarily. Carotene makes up anywhere from 1 to 90 per cent of the potency. Calculations of potency from direct determinations of carotene and vitamin A are somewhat uncertain because 1 mg. of carotene in butter may yield anywhere from 0.16 (3) to 0.6 (5) mg. of vitamin A as measured by activity. It would be valuable to make comparative studies of vitamin A and carotene on a much larger number of cows than any of these workers have studied. Determinations of vitamin A by $SbCl_3$ have been greatly simplified but are still time-consuming. The presence of an inhibitor in summer milk fat prevents development of the color (4) unless the fat is saponified. Methods have been developed for the extraction of carotene and vitamin A from whole milk (12, 15) when the samples are too small for convenient separation of the milk fat.

SUMMARY

The average carotenoid content of the commercial, bottled market milk in New York State was 3.4 mg. per liter of melted fat in winter and 10.1 in summer. The corresponding values for average Holstein milk from the Cornell herd was 3.49 and 5.78; for Jersey milk 5.87 and 10.5 and for Guernsey milk 8.50 and 16.4.

Bottled market milk ranged from 1.51 to 7.26 in winter and from 4.85 to 24.6 in summer. Individual variations within the same breed are much larger than the variations among average values for the different breeds. Individual samples of Holstein milk in June ranged from 2.72 to 10.6, and Guernsey milk from 10.4 to 20.8.

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DIFFERENCES IN ADSORPTION OF SOLID AND LIQUID FAT GLOBULES AS INFLUENCING THE SURFACE TENSION AND CREAMING OF MILK

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This investigation was undertaken to see if there was a reversible difference in adsorption, on the surfaces of solid fat globules, or fat globules which have passed through the solidifying zone of temperature, on the one hand, and liquid fat globules on the other. The factors influencing gravity creaming and cream viscosity, as well as a number of anomolous behaviors of milk and cream may be interpreted as indicating such a difference. Differences in surface tension and gravity creaming were used as indications of the correctness of this hypothesis. It has wide practical applications in the handling and processing of milk and its products, and has been made the basis of many of our investigations during the past several years.

The most definite indication which we found in the literature, of the correctness of this hypothesis, is the report by Hekma (4), who showed that deeper layers of gravity cream were obtained when centrifugally separated skimmilk was used in making recombined milk than when gravity separated skimmilk was used. He believed that the clumping agent was thrown from the surface of the fat globules by the centrifugal force of the separator, and consequently appeared in larger amounts in the centrifugally separated skimmilk. If his experiments were carried out in the usual manner, the gravity skimmilk was removed from fat globules while in the solid state, and the centrifugally separated skimmilk from fat globules while in the liquid state. The difference therefore might be due to the physical state of the fat and not to method of separation.

Burri and Nussbaumer (3) found that previously cooled milk had a lower surface tension at 20° C. than milk which had not been cooled. This observation has been confirmed by Bauer (1), Quagliariello (7), and Mohr and Brockmann (5). Bauer (1) and Mohr and Brockmann (5) showed that the low surface tension produced by cooling could be increased again to approximately normal by warming the milk to 50–60° C.

Mohr and Brockmann (5) conclude that the material adsorbed on the surface of solid fat globules differs from that adsorbed on liquid fat globules.

EXPERIMENTAL

Method of surface tension measurement

All surface tension measurements reported in this paper were made at 25° C. Both room and solution were adjusted to this temperature.

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A wire loop, sealed to one end of a microscope slide, was used to suspend a slide from one arm of a chainomatic balance. The other end of the slide was dipped into the center of the surface of the liquid contained in a beaker 7 cm. in diameter, held on an adjustable support over the pan of the balance.

The surface tension was calculated as being proportional to the weight necessary to pull the edge of a microscope slide from the surface of milk as compared to the weight necessary to pull the same slide from a pure water surface. The surface tension of water was taken as 71.97 dynes at 25° C. The weights required to pull the different slides used from the surface of water ranged from 0.4530 to 0.4662 grams.

The surface tension of each sample of milk was determined with two different slides. Adjustments were made so that the surface broke from each end of the slide at the same time, and when the balance pointer was at zero. The slide was pulled from the surface approximately 30 seconds after stirring the milk. Duplicate determinations with the different slides did not deviate more than 0.10 dynes and most of the deviations were about 0.03 dynes.

Preparation of milk samples

Raw whole milk was divided into three parts and treated as follows:

(1) Original whole milk as a control.
(2) Milk held at 0–5° C. for 2 hours and then separated at 5°–10° C. with the collecting pan warmed slightly to permit the cream to flow. The skimmilk was reseparated.
(3) Milk held at 60° C. for 30 minutes and separated at 60° C.

The effect on surface tension, of warming and cooling of the products obtained above, as well as of whole milk made by recombining the proper amounts of skimmilk and cream, was determined. A list of the products studied is given below:

1. Original whole milk.
2. Milk recombined from 60° C. skimmilk and 60° C. cream.
3. Milk recombined from 5° C. skimmilk and 5° C. cream.
4. Milk recombined from 60° C. skimmilk and 5° C. cream.
5. Milk recombined from 5° C. skimmilk and 60° C. cream.
6. Skimmilk separated at 5° C.
7. Skimmilk separated at 60° C.
8. Cream separated at 60° C.
9. Cream separated at 5° C.

In the recombining, care was taken to prevent churning. The recombined milks, containing the same fat content as the milk used in separation, were prepared as soon as possible after the products were obtained. The cream was always added to the skimmilk. The products were cooled at once in ice water.

Surface tension measurements

After each product had been held in ice water for at least 2 hours, it was

warmed to 25° C. and the surface tension was measured. The product was then warmed to 60° C. and cooled to 25° C., and the surface tension was again measured. The entire set of experiments was performed on three different lots of fresh raw milk. The relative effects were almost identical with each lot of milk. The average of the values obtained is presented graphically in Figure 1.

The skimmilk separated at a high temperature had a higher surface tension than the skimmilk separated at a low temperature. The failure of the surface tension of skimmilk to be affected by warming and cooling is in agreement with the investigations of others. However, the cream which was separated at 60° C., and its combination with skimmilk separated at 5° C., showed little alteration in surface tension produced by previous warming or cooling, whereas the cream separated at 5° C., the other recombined milks, and the original milk, showed a difference in surface tension due to previous warming and cooling.

Experiments similar in type to those presented in Figure 1 were carried out, in which the separation was accomplished by centrifuging in glass tubes in a laboratory centrifuge, placed in a cold room in one case and in a warm room in the other. The results were in general agreement with those presented in Figure 1. Therefore, the differences cannot be attributed to the mechanical action or aeration encountered in the ordinary centrifugal cream separator.

The definite differences in surface tension presented in Figure 1 indicate that the adsorbed material on the surface of solid fat globules differs from

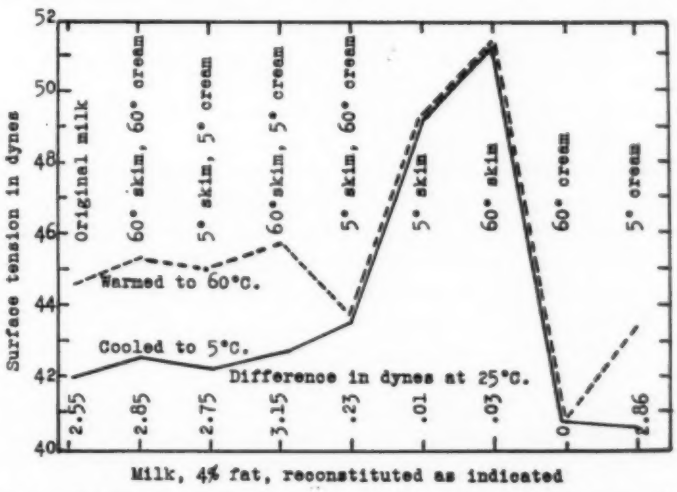

FIG. 1. Surface tension at 25° C. of recombined milk as affected by warming and cooling.

that on liquid fat globules. This is in agreement with our interpretation of the results of Hekma's experiments as being due to a difference in adsorption between the solid and liquid fat globules, and not due to the effect of the separator in freeing the surface, since the cream was separated by the centrifuge in both cases.

Milk which has been heated to temperatures sufficiently high to destroy the clumping property of the fat globules does not show the change in surface tension due to warming and cooling. Heated milk, even after cooling and warming to 25° C., has the surface tension corresponding to warmed milk cooled to 25° C. This renders doubtful Quagliariello's (7) explanation that the lowering of the surface tension produced by cooling is caused by the extrusion of the lower glycerides, due to the solidification of the fat globules.

Gravity creaming as an agglutination process

One of the principal objects of these experiments was to throw light on the process involved in the agglutination of the fat globules, a process which is necessary to obtain gravity creaming of market milk. At the Hoorn Experiment Station in Holland, studies had previously been made of the agglutinating power of various protein fractions obtained from the blood of cattle. Brouwer (2) found that the euglobulin fraction exerted agglutinating power on the fat globules of milk. Sumner, Howell and Zeissig (8) have isolated and crystallized an agglutinin called concanavalin A, from the jack bean, which has power to agglutinate the fat globules of milk if added in fairly large amounts. This material will agglutinate heated milk as well as homogenized milk. Its agglutinating power seems to be more marked when the fat globules of milk are in the liquid state. This temperature effect is apparently the reverse of that of the natural agglutinin of milk, at least in the amounts in which it is present normally.

Our work on surface tension and the investigations cited led us to adopt the following working hypotheses as a partial explanation of the natural clustering which results in the gravity creaming of whole milk:

(1) The clustering of fat globules is due to an agglutinin in the milk.
(2) The agglutinin tends to be more strongly adsorbed, and consequently exerts its greatest action on the solid or solidifying fat globules.
(3) The agglutinin is not adsorbed on liquid fat globules, and consequently does not clump them.
(4) The agglutinin is altered or rendered inactive by heating to high temperatures.

The correctness of these hypotheses has been greatly strengthened by the isolation of the agglutinin which is present in milk in very small amounts, and by the preparation of fractions in which it is almost entirely lacking. The methods of isolation and a study of the properties of this agglutinin will be reported later. The essential correctness of these ideas as applied to natural milk is shown by the following creaming experiments.

In accordance with the hypothesis that the agglutinin is adsorbed on the solid but not on the liquid fat globules, the combination of skimmilk separated at a high temperature (45–60° C.) with cream separated at a low temperature (0–10° C.) shows good creaming properties, while the reverse combination shows poor creaming properties. The recombination of the creams with their own skimmilks shows approximately the natural creaming properties of the original milk. However, a slight decrease in creaming was often found when the products which were separated cold were recombined. After the cream and skimmilk were mixed, the mixture was heated to 45–50° C. and was then cooled in the ice water for creaming. A large number of experiments of this type were carried out. Some typical examples are presented in Table 1.

TABLE 1

Cream volume obtained on milk recombined from cream and skimmilk separated at 45° C. and at 10° C.

Expt. No.	Reconstituted milk made from				Cream volume on milk after holding at 2°–5° C.			
	Cream		Skimmilk					
	Sep. temp. °C.	Heat treat. °C.	Sep. temp. °C.	Heat treat. °C.				
Expt. A—Fat content 6.0%					Hours held			
					3	8	24	48
					%	%	%	%
1	45	Raw	45	Raw	30	28	23	20
2	45	Raw	10	Raw	0	0	15	16
3	10	Raw	10	Raw	26	23	20	18
4	10	Raw	45	Raw	28	25	22	20
Expt. B—Fat content 5.8%					Hours held			
					2	4	24	
					%	%	%	
5	45	Raw	45	Raw	32	28	22	
6	45	Raw	10	Raw	0	0	18	
7	10	Raw	10	Raw	26	24	18	
8	10	Raw	45	Raw	30	27	21	
9		Original	milk		24	22	18	
Expt. C—Fat content 4.0%					Hours held			
					4	12	24	36
					%	%	%	%
10	45	Raw	45	Raw	17	13	13	11
11	45	70	45	Raw	17	13	13	11
12	45	Raw	10	Raw	0	8	8	9
13	45	70	10	Raw	0	7	7	8
14	10	Raw	45	Raw	20	15	14	12
15	10	70	45	Raw	18	14	13	12
16	10	Raw	10	Raw	16	14	13	12
17	10	70	10	Raw	8	10	10	10
18	45	Raw	45	70	0	6	6	7
19	45	Raw	10	70	0	2	3	5
20	10	Raw	45	70	10	11	10	10
21	10	Raw	10	70	10	11	10	10

Evidence was presented by Van Dam and Sirks (9), Hekma (4), and Palmer, Hening and Anderson, (6), that the agglutinating agent resides in the plasma. The theory presented here indicates that plasma is largely responsible for the clumping only when the milk is separated while the fat is in the liquid state. This is a confirmation of previous work, but indicates that the plasma investigated by previous workers was obtained while the fat was in the liquid state. If the plasma is separated from the fat while the fat globules are in the solid state, then the fat globules may actually exert a more important influence on creaming than the plasma. This is indicated in Table 1 by the effect of heating some of the samples of cream and skimmilk before recombining them. Paired experiments 10–11 and 12–13 indicate that heating the cream did not appreciably reduce the cream layer formed on the recombined milk. Reductions due to heating the cream were found, however, if the cream was separated while the fat globules were solid, as indicated by pairs 14–15 and 16–17. The most definite effect, however, is shown in experiments 18–21, in which heated skimmilk when combined with

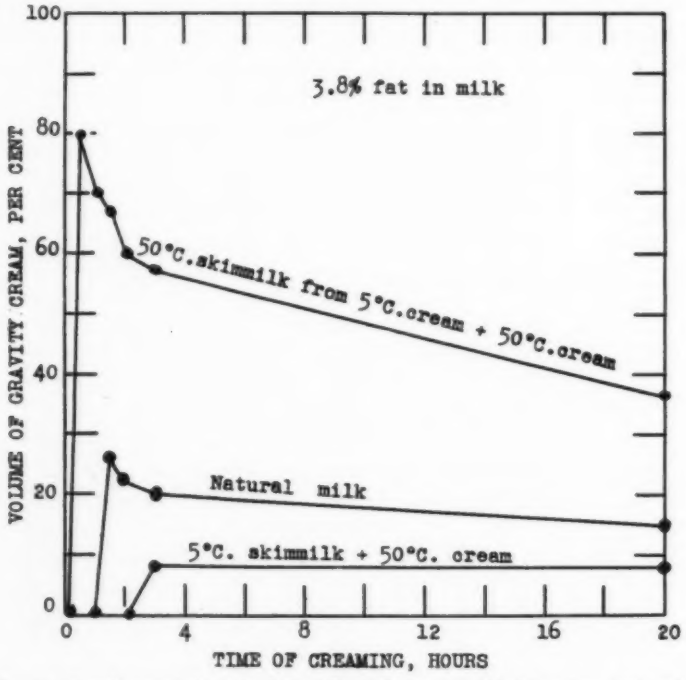

FIG. 2. Gravity creaming of whole milk made by recombining cream with skimmilk which had been depleted and with skimmilk which had been enhanced in agglutinin content.

cream separated at 45° C. formed little cream, while heated skimmilks, recombined with cream separated with the fat globules in the solid state, showed appreciable creaming.

These experiments indicate obvious methods of concentrating the agglutinating material. One procedure used, which tends to bear out the correctness of our hypothesis, is the following: Cream was allowed to rise on cold, raw milk. The skimmilk was withdrawn from beneath the cream layer and the cream was then concentrated by separation at 5–10° C. The cream was then warmed to 50° C. and separated again, so that what might be called 50° C. cream plasma was obtained. The separation of the cream while the fat was in the solid state concentrated probably three-fourths of the agglutinin of the milk in the cream. When the cream was heated to 50° C. the fat surface was freed of the agglutinin which then appeared in the plasma phase. The same high-temperature-separated cream was used to produce recombined 3.8 per cent fat milk from 50° C. cream plasma and from the skimmilk obtained originally in the first cold separation. The results of a typical experiment are presented in Figure 2. The cream layers obtained from milk recombined from 50° C. cream plasma were truly remarkable. They formed 10 minutes after the milk was cooled. The layer when first formed occupied from 80 to 90 per cent of the volume, and after standing cold for 20–24 hours the cream volume was usually 35–45 per cent. The usual reduced values were shown by the cream volumes obtained when the skimmilk, separated while the fat globules were solid, was used in recombining.

DISCUSSION

The effect of the physical state of the fat globules at the time of separation, on the properties of the skimmilk, whey and cream, have been studied in connection with foaming, churning, cream whipping, lipase activity, creaming and surface tension. This article is limited to some of the effects on creaming and surface tension.

In natural milk, presence of the agglutinin in the plasma phase is apparently associated with an increase in surface tension and liquefaction of the fat; its absence from the plasma phase or presence on the surface of the fat globules is associated with a lower surface tension and the solidification of the fat. Whole milk containing the active agglutinin shows the effect of previous warming and cooling, on the surface tension. The high-temperature-separated skimmilk containing the agglutinin has a higher surface tension than does the low-temperature-separated skimmilk in which the agglutinin is largely absent. Cream separated while the fat is in the solid state contains the agglutinin and consequently shows the effect of previous warming and cooling on surface tension. Cream separated while the fat is in the liquid state contains little agglutinin, and does not show the effect of previous warming and cooling on the surface tension. The combination of 5° C. skimmilk

and 60° C. cream has a relatively low surface tension, contains little agglutinin, and shows little effect of previous warming and cooling, on the surface tension.

Whether the agglutinin is actually the material which influences the surface tension is not established. One would expect that, if the agglutinin were liberated to the plasma phase and the surface tension were affected at all, it would be lowered. Protein systems usually do not meet all of the requirements demanded in the strict application of the adsorption theory as advanced by Gibbs. Such an effect is therefore not impossible. There are, however, other possibilities.

A displacement of substances on the surface of the fat globule may occur. When the agglutinin is adsorbed on the surface of the fat globules a surface-tension-reducing substance may be displaced, which then appears in the plasma phase and lowers the surface tension. When the agglutinating agent is liberated from the fat surface the surface-tension-reducing substance may be again adsorbed on the fat. This last hypothesis is a little like that proposed by Quagliariello (7), but involves a heat labile protein as one component and thus the exchange would be stopped by heating. It gains support from the fact that the skimmilk separated at 5° C. has poor foaming properties, while skimmilk separated at 50° C. has marked foaming properties; and from the fact that when low-temperature-separated skimmilk is extracted with petroleum ether its foaming properties then approach those of the high-temperature-separated skimmilk. The difference between the two types of skimmilk can hardly be due to less efficient separation at the lower temperature, because repeated separations of the skimmilk at higher temperatures do not alter the relationships.

There are several other possible explanations.

CONCLUSIONS

1. Adsorption on the surfaces of liquid and of solid fat globules in normal unheated milk is different.

2. The difference in adsorption due to the difference in the physical state of the fat markedly affects surface tension, foaming, and gravity creaming.

3. The clumping of the fat globules which results in gravity creaming is produced by an agglutinating substance.

4. The agglutinating substance is adsorbed on the surface of the solid or solidifying fat globules and not on the surface of the liquid fat globules.

5. The agglutinating substance is concentrated in cream separated at low temperatures and is relatively absent in the corresponding skimmilk, and it is relatively low in cream separated at high temperatures but is present in the corresponding skimmilk.

6. The concentration of the agglutinating substance can be greatly increased by first separating cream at a low temperature and then separating it

to a higher fat content at a higher temperature at which the fat is liquid. The cream plasma obtained at this higher temperature is very active in agglutinating power.

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THE RIBOFLAVIN VALUE OF MILK[1]

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INTRODUCTION

Milk is recognized today as a foremost source of riboflavi.. (vitamin G) in human dietaries. It is desirable, therefore, that our knowledge of the variations of this important constituent of milk be as extensive as possible. Hunt and associates (10, 11, 12) studying the influence of the ration on the vitamin G content of milk reported better rat growth on milk from cows on pasture than on milk from cows on dry feed. Whitnah and associates (18), using the rapid fluorimetric method, have reported on the riboflvain content of milk samples collected in different months and correlated with other constituents of the milk.

A recent study, reported from this laboratory by Kramer and coworkers (13), showed significant variation, as determined biologically, in the riboflavin value of milk produced during the first month of lactation. The present investigation is a continuation of this study and its purpose was to secure information concerning the riboflavin value of milk produced under different well defined herd feeding conditions.

PROCEDURE

Samples of milk (Table 1) for these experiments were secured from the Kansas Agricultural Experiment Station herd. Twenty-four hour collections of milk were made and composite samples retained for riboflavin determinations. All samples of milk were held below 0° C. until used. A description of the samples used and types of rations fed appears in Table 1.

For the biological assays, the Bourquin-Sherman (6) method was used. This method has been shown by Bisbey and Sherman (5) and Bessey (4) as reliable for quantitative estimation of the flavin content of foods. The samples of milk were fed as supplements to the basal diet at the rate of 3 grams per day for 6 days a week. The standard, fed for reference to the positive controls, was riboflavin, PX grade, secured from the Biological and Chemical Laboratories of the Borden Company, Research Division. It was

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TABLE 1

Riboflavin determinations of milk

Milk samples						Biological assay							Fluorimetric determinations		
						Rats used					Estimated riboflavin				
Sample		Date of collection	Sample number	Fat	Total solids	Daily portion	Number	Average time depleted	Average initial weight	Average gain	Per portion	Per gram milk	Riboflavin per gram milk	Variation from biological value per gram	
				%	%	gm.		Days	gm.	gm.	Micrograms	Micrograms	Micrograms	Micrograms	%
	7 Holstein cows														
1	Herd ration, no pasture	9– 3–36	1	3.5	12.07	3	10	13	49	40	6.0	2.0	1.76	−0.24	−12
2	Herd ration, fall pasture	12– 3–36	2	3.1	11.72	3	10	12	47	50	7.5	2.5	1.88	−0.62	−25
	5 Jersey cows														
3	Herd ration, no pasture	9– 3–36	3	4.5	13.89	3	10	13	48	43	6.5	2.2	2.3	+0.10	+ 4
4	Herd ration, fall pasture	12– 3–36	4	5.6	15.30	3	10	13	47	56	8.5	2.8	2.55	−0.25	− 9
	4 Holstein cows														
5	Herd ration, no pasture	4–14–37	5	3.2	11.5	3	10	16	49	31	4.8	1.6			
6	Herd ration, spring pasture	5–12–37	6	3.3	11.8	3	11	15	49	31	4.8	1.6			
	4 Jersey cows														
7	Herd ration, no pasture	4–14–37	7	5.2	14.67	3	10	15	48	40	6.0	2.0			
8	Herd ration, spring pasture	5–12–37	8	5.1	14.53	3	10	15	50	45	6.8	2.3			
	4 Guernsey cows														
9	Herd ration, no pasture	4–14–37	9	5.9	14.21	3	10	15	49	44	6.6	2.2			
10	Herd ration, spring pasture	5–12–37	10	5.2	14.50	3	10	15	50	40	6.0	2.0			
	7 Holstein cows														
11	Experimental ration	9– 9–36	11	4.0	11.21	3	10	13	46	46	7.0	2.3	2.20	−0.10	− 5
	Station herd														
12	Herd ration	1–15–37	12	4.0	12.75	3	13	16	45	40	6.0	2.0			
						micrograms									
	Negative controls					0	19	14	46	0					
	Controls for reference curve														
	Riboflavin					2.5	10	13	46	17					
	Riboflavin					5.0	9	14	49	33					

Description of samples used:

Nos. 1, 3, 5, 7, 9 herd ration of alfalfa hay, silage and grain.

Nos. 2, 4 rye pasture—Holsteins, 2 weeks—Jerseys, 3 weeks.

Nos. 6, 8, 10 spring pasture for 3 weeks.

No. 11 experimental ration, No. 2 upland prairie hay and grain without green feed or pasture for over two years.

No. 12 winter milk from college herd representing four breeds on herd ration of alfalfa hay, silage and grain.

fed at two different levels; 2.5 micrograms and 5 micrograms, 6 days per week. For the biological assays, all groups but one contained at least 10 rats. The animals (Wistar Institute strain) were confined in cages having raised wire screen floors and checked daily for evidence of coprography.

A number of the milk samples were also assayed fluorimetrically using the method developed by Whitnah and associates (17).

DISCUSSIONS

The results are presented in Table 1. Although the feeding tests extended over a period of ten months, the groups of rats showed satisfactory uniformity as indicated by the average lengths of depletion periods and average initial weights. The composite gain curves (Figure 1) show that sup-

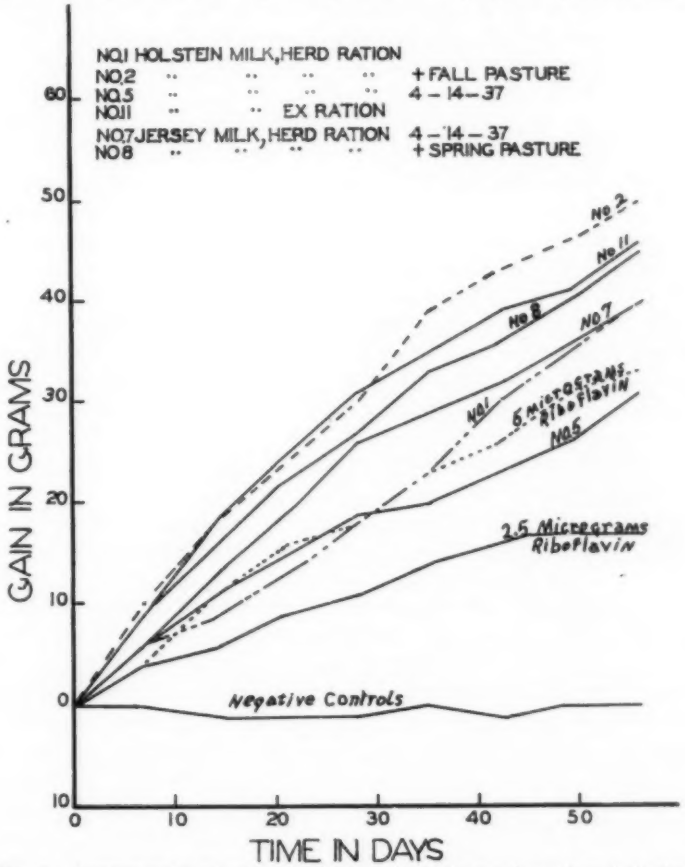

FIG. 1. Average gains of rats fed milk and riboflavin supplements as indicated.

plements produced regular growth response throughout the 8-weeks experimental period. A flattening of the curve during the last two weeks of feeding is observed for the smallest supplement, namely, 2.5 micrograms riboflavin. However, this curve compares well with that of the rats receiving twice the amount of this supplement. The total gains for the 8-weeks period on these two levels were 17 and 33 grams respectively, which is almost in the ratio of 1 to 2. These riboflavin curves, therefore, appear reliable for reference, since the growth response was almost in direct proportion to the amount fed. The average gain per week in each case checked with the curve presented by Ansbacher and associates (1).

The riboflavin content of a daily portion of each milk sample was estimated both by comparison of the composite gain curves with the reference curves and also by direct proportion between total gains for eight weeks as compared with total gains shown on the reference curves. These estimates were made on the assumption that growth responses from larger supplements were in direct proportion to the riboflavin content. Ansbacher, Supplee, and Bender (1) have suggested that the response diminishes as the supplements become large. However, none of the portions here used produced gains sufficient to reach this upper level of diminishing returns. Only two 8-weeks gains, those of 50 and 56 grams (Table 1) seemed large enough to be questioned. Values estimated from these gains were checked fluorimetrically, so the biological values may be considered reliable. The estimated riboflavin values are expressed as micrograms per gram of milk.

Some of the estimates of riboflavin content based on biological data were compared with values obtained from readings with the Eveready Fluoray lamp and are in reasonable accord with these values. In no case were the fluorimetric readings excessively high; rather, they tended to be lower than the estimates derived from biological data. The maximum difference between values determined by the two methods was 25 per cent with an average difference of 10 per cent.

Biological assay of samples No. 1 and No. 3, collected in September at the end of an abnormally dry summer, indicated the presence of at least 2 micrograms of riboflavin per gram of milk. Later samples (No. 2 and No. 4) collected in December after the cows had access to good pasture for periods up to one month, gave values approximately one-fourth higher. On the other hand, samples No. 6, 8, and 10, collected from other groups of cows on pasture the following spring did not show the expected increase when compared with milk samples collected from the same cows near the end of the winter feeding period (No. 5, 7, and 9). Only in the case of the Jersey composite (No. 8) was a small increase observed in the riboflavin content of the milk which might be attributed to the influence of the supplemental pasture. The Holstein sample (No. 6) showed no increase in riboflavin as a result of pasture feeding, while the biological assay of the milk from the group of Guernseys (No. 10) actually gave a small decrease.

It should be emphasized that throughout the Central Plains area the summer of 1936 was one of the driest on record with abnormally high summer temperatures prevailing. The station herd was without green feed from June until October, the normal pasture season, and barn feeding of the winter herd ration was followed. The lack of pasture combined with the excessively hot weather (60 days with temperature readings 100° F. or over) represented extreme conditions which undoubtedly had its effect on the physiological behavior of the cows involved. Regan and Richardson (14) have studied the effect of environmental temperature on high producing cows in a large psychrometric room with air movement and relative humidity closely controlled. These workers observed that as the temperature was elevated above the pyrexial point (80 to 85° F.) an alteration occurred in the characteristics of the milk produced which included a lowering of the casein and solids-not-fat content. In the present experiment the milk production of the cows was lowered as a result of the extreme heat and it is possible that the secretion of riboflavin was also affected, to return to more normal levels, possibly even with some increase, after a period of cooler weather and access to pasture. This is somewhat conjectural and offers little aid in explaining the inconsistent results obtained the following spring. Similar behavior has been observed with respect to the vitamin C in milk which is apparently more responsive to seasonal and climatic changes than to the feed which the cow receives. Bechdel and associates (2, 3) have found that the vitamin B complex may be synthesized by microorganisms in the rumen of the cow and that the amount in the milk is not dependent on the amount in the ration. Gunderson and Steenbock (9) showed that milk produced on pasture and fresh green alfalfa did not contain any more vitamin B (complex) than milk produced on silage and dry feed. These workers observed that increasing the vitamin B intake by feeding wheat germ had no discernible effect both absolutely and in relation to the amount of milk secreted on the vitamin B content of cow's milk. While it is not possible to interpret the foregoing work in terms of riboflavin, which is one of the ensemble of known B factors, it does appear to support the conclusion that the ration is not a major factor influencing the riboflavin content of milk.

A statistical analysis of all results in the present study grouped with respect to before and after pasture feeding and involving growth records of some 50 rats in each instance showed no significant increase which might be attributed to the addition of pasture to the ration. A difference of 0.2 $\pm$ .18 was obtained which is less than would ordinarily be considered as significant.

In these experiments Jersey and Guernsey samples gave slightly higher estimated riboflavin values than comparable samples of Holstein milk. Attention is called to the fact that the milk produced by the Holsteins on

the restricted ration (dry lot for over two years) was at least as rich in riboflavin as samples No. 1 and No. 3 and as the sample of winter milk (No. 12) from the station herd. In terms of total milk production, the Holstein cows on the restricted ration, because of their average milk yield, produced only approximately half as much riboflavin per cow per day as did the Holsteins in the station herd. Also, because of higher daily milk yield these Holsteins produced greater average daily yields of riboflavin than the Jerseys or Guernseys.

The growth records of the rats receiving 2.5 and 5.0 micrograms riboflavin in the present investigation would indicate that a Bourquin-Sherman unit is equivalent to about 3.6 micrograms riboflvain. Estimates ranging from 2.0 to 4.0 micrograms of riboflavin equivalent to one Bourquin-Sherman unit have been reported in the literature (4, 7).

Euler and Adler (8) have estimated that milk contains 2 to 3 micrograms of riboflavin per ml. In the present study an average riboflavin value for all milks tested indicated 2.1 micrograms per gram with a range of 1.6 to 2.8 micrograms. On this basis a quart of this milk would furnish approximately 542 Bourquin-Sherman units, which is only slightly less than the tentative figure of 600 units used at present in determining the adequacy of human dietaries.

SUMMARY AND CONCLUSIONS

Biological assays of samples of milk secured in September, 1936, following an abnormally dry summer with no green pasture available, showed riboflavin values of about 2 micrograms per gram of milk. Later, after the cows had been on pasture, values approximately 25 per cent higher were secured. However, data obtained the following spring did not show the expected increase as a result of pasture feeding when compared with values on the winter ration. When all values representing before and after pasture feeding were submitted to statistical analysis no significant difference was found. It is concluded, therefore, that under the conditions of this study the rations did not have any very significant effect on the riboflavin content of milk. It is suggested that climatic and seasonal factors may be of more importance. In further support of this is the fact that the milk from the experimental herd maintained without green feed for over two years yielded milk at least as rich as the milk from the station herd, presumably fed a more desirable ration.

The average riboflavin value for all samples of milk tested was 2.1 micrograms per gram of milk. On this basis a quart of milk would furnish approximately 542 Bourquin-Sherman units.

The riboflavin determinations of the milks by a fluorimetric method gave results valuable as checks and comparable to biological assay findings. The maximum difference between the biological findings and the Fluoray lamp

readings was 25 per cent in a limited number of determinations with an average difference of ± 10 per cent. While consistently lower the fluorimetric results showed the same general trend.

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WATER SORPTION BY DRY MILK SOLIDS. II. THE RELATION BETWEEN VOLUME CONTRACTION AND THE DEGREE OF SORPTION

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The first paper of this series (1) has shown the extent of volume contraction of dry milk solids, prepared by different processing treatments, when exposed to a large amount of water. The present paper deals with the volume contraction exhibited by the dry milk solids at different degrees of sorption. The maximum volume contractions as reported represent values characteristic of the different samples, and it is important to know the water content to which these are equivalent. According to certain workers (2, 3), volume contraction accompanying water sorption represents a decrease in the specific volume of water of 30–40 per cent. This means a volume contraction of 3–4 cu. mm. per gram of sorbed water. Whether these values are applicable to dry milk solids is not known. The data to be presented here will establish this relationship.

EXPERIMENTAL

The changes occurring when small quantities of water are added to a large amount of solids are difficult to measure accurately. It was decided, consequently, to measure the volume contraction of the solids after they had been allowed to sorb predetermined quantities of water. From values thus obtained the volume contraction occurring in dry milk solids of definite water content can be determined; and the extrapolation of these data will give the maximum volume contraction occurring at zero water content of the sample, together with the water content above which no volume contraction will occur.

The samples used were from the same source as those reported previously (1). They consist of eight samples of dry milk solids, identified in Table 1.

TABLE 1

Identification of samples

Sample no.	Preheat temperature 30 minutes		Manufacturing process
1	71.1° C.	160° F.	spray
2	76.6	170	
3	82.2	180	
4	93.3	200	
5	71.1	160	atm. roll
6	76.6	170	
7	82.2	180	
8	93.3	200	

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Volume contraction was measured as previously described (1, 4). To determine how the water content affects the volume contraction, each sample was made up to a definite water content by adding a known quantity of water to a weighed amount of dry milk solids; by allowing sorption to take place for 24 hours, since the previous results had indicated that sorption was usually complete within that time, and then by measuring the residual volume contractability of the system.

RESULTS

The results are expressed as volume contraction (C), representing cubic millimeters per gram of solids; and as degree of sorption (i), representing $\frac{\text{weight of water sorbed}}{\text{weight of solids}} \times 100$—in other words, the sorbed water expressed as percentage of the dry material.

Table 2 shows the volume contraction (C), of each sample after being made up to different water contents:

According to these data, after a sample has been allowed to sorb a quantity of water, the extent of volume contraction is less than before and is further

TABLE 2

The volume contraction of dry milk solids of different water contents

Water content per cent of dry material	Sample No.							
	1	2	3	4	5	6	7	8
2.0	.....	.....	63.4	64.2	.....	.....	38.0	42.5
2.1	.....	98.0	.....	.....	.....	.....	.....	.....
2.4	75.8	.....	.....	.....	.....	.....	.....	.....
2.5	.....	.....	.....	51.0	.....	50.0	.....	.....
2.9	.....	.....	53.0	.....	30.2	.....	.....	35.2
3.8	.....	.....	.....	.....	.....	.....	30.2	.....
4.4	58.0	.....	.....	.....	.....	.....	.....	.....
5.0	.....	.....	.....	.....	21.8	36.0	.....	27.5
6.4	53.0	.....	.....	.....	.....	.....	.....	.....
7.1	.....	59.0	.....	.....	.....	.....	.....	.....
7.5	.....	.....	.....	.....	.....	11.2	17.4	20.0
8.4	47.0	.....	.....	.....	16.0	.....	.....	.....
10.0	37.2	.....	31.0	31.0	.....	.....	.....	.....
11.0	.....	.....	.....	.....	8.3	.....	.....	.....
12.0	.....	.....	.....	.....	.....	.....	7.1	.....
12.1	.....	38.0	.....	.....	.....	.....	.....	.....
12.4	31.0	.....	.....	.....	.....	.....	.....	.....
12.5	.....	.....	.....	.....	.....	4.3	.....	10.6
13.0	.....	.....	.....	.....	4.3	.....	.....	.....
15.3	.....	.....	.....	.....	.....	.....	2.1	.....
17.1	.....	26.1	.....	.....	.....	.....	.....	.....
17.3	.....	.....	.....	8.5	.....	2.0	.....	.....
18.0	.....	.....	7.5	.....	.....	.....	.....	.....
19.7	11.0	.....	.....	.....	.....	.....	.....	.....
20.0	.....	.....	5.0	.....	.....	.....	.....	.....
22.9	.....	.....	.....	2.0	.....	.....	.....	.....
27.1	.....	10.9	.....	.....	.....	.....	.....	.....
27.5	2.0	.....	.....	.....	.....	.....	.....	.....
32.1	.....	6.7	.....	.....	.....	.....	.....	.....
33.9	.....	2.8	.....	.....	.....	.....	.....	.....

reduced as the quantity of water pre-sorbed is increased. From these data one should be able to construct curves and, by extrapolating to the axes, to obtain reasonably accurate values for the volume contraction (C) at 0 per cent water and for the degree of sorption (i) above which no further contraction will occur. Since the curves are nearly tangent to the ordinate and abscissa at these values, the exact point of intersection is difficult to determine; but if the logarithms of these values are plotted, curves result which, when extrapolated, intersect the axes nearly at right angles, thus permitting reasonably accurate location of the zero points. Curves thus obtained appear in Figure 1.

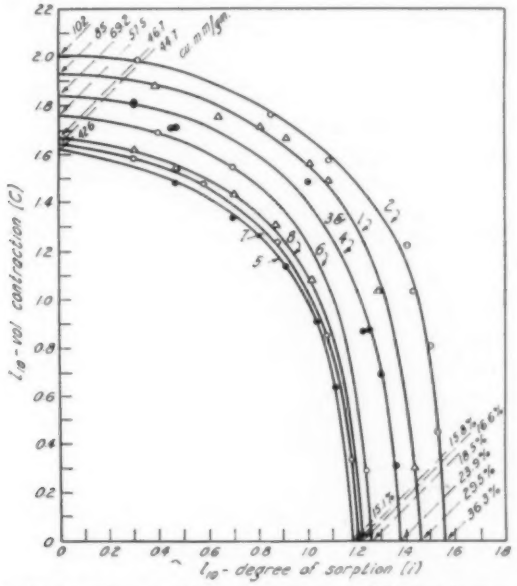

FIG. 1. Logarithmic values of volume contraction at different degrees of sorption.

As will be observed, the maximum volume contraction ranges from approximately 42 cubic mm. per gram of solids to 102 cubic mm.; and these values correspond to approximately 15 per cent sorption up to 36 per cent sorption if the extrapolations are assumed to be valid. Pyenson and Dahle (5), using the cryoscopic method, have found that dry milk solids prepared by the vacuum drum process "bind" 61.1 per cent of water when fresh, 40.3 per cent when four weeks old, and 40.1 per cent when eight weeks old if stored in a closed container.

Table 3 shows the degree of sorption (i) corresponding to the maximum volume contraction (C) as obtained by extrapolation, together with the ratio

between them in terms of cubic millimeters per 1 per cent water for the different samples.

TABLE 3

The maximum volume contraction and maximum degree of sorption of different samples of dry milk solids

Sample No.	C	i	C/i
1	85.0	29.5	2.87
2	102.0	36.3	2.81
3	69.2	23.9	2.89
4	69.2	23.9	2.89
5	42.6	15.1	2.83
6	57.5	18.5	3.10
7	44.7	15.8	2.83
8	46.7	16.6	2.82
Average	.....	.....	$2.88 \pm .06$

As this table reveals, the degree of sorption for the differently processed samples is greatest for those preheated at 76.6° C. (170° F.). The effects of excess heat are shown in the lower values for the samples prepared by the roller process and by preheating above 76.6° C. (170° F.) for the spray process. These data express quantitatively the effects of the processing treatments shown previously (1).

DISCUSSION

The experimental value of the constant found for the volume contraction per unit of water sorbed by dry milk solids (namely, $2.88 \pm .06$ cubic mm. per one per cent water) falls somewhat below the expected value of 3–4 cubic mm. per 1 per cent water. Several reasons may be suggested. Syneresis resulting from the aging for 24 hours may be ruled out because the maximum volume contraction (C) is determined from dry or nearly dry material; if syneresis should occur at higher water contents, then the values for degree of sorption would be too low. Larger values for degree of sorption with the same values for maximum contraction would result in a constant even farther away from the expected value.

A more logical explanation lies in the possibility of lactose hydration. Sucrose, as is well known, forms a hexahydrate in solution (6). Leighton (7) suggests from his studies that lactose acts like sucrose in solution and forms a hexahydrate. Although data on the point are fragmentary, those given in the International Critical Tables for freezing-point depressions (8) indicate some degree of hydration of lactose in solution. Hudson (9) believes that only the alpha equilibrium form is hydrated in solution. It seems reasonably conclusive that lactose molecules in solution are hydrated to a greater or less degree.

Evidence regarding the volume changes resulting from solution of lactose is more positive. The Associates of Rogers (10) cite evidence to show that lactose in 54 per cent solution exhibits a volume contraction of 11 cubic milli-

meters per gram of lactose. Schmoeger's data (11) on densities of different concentrations of lactose also indicate a volume contraction at the relatively higher concentrations, as is evidenced by the fact that the determined densities exceed the theoretical at concentrations of 10 per cent lactose and above. Below this in the range of 2–5 per cent lactose, however, the measured density of the solutions corresponds almost exactly to the theoretical. Also, experiments with the apparatus used in these studies with the same concentrations of lactose as in the dry-milk studies—namely, 2–3 per cent—have failed to reveal any significant volume change. Possibly—to judge from this evidence—some of the sorbed water is used in hydrating the lactose in solution but does not manifest itself in volume contraction, thus resulting in a volume contraction/degree of sorption ratio smaller than the expected value.

SUMMARY

1. The volume contraction of dry milk solids prepared by different processing treatments was determined after different amounts of water had been added to the dry material.

2. From these data, curves were constructed which, when extrapolated to zero water concentration and zero contraction, gave values for maximum volume contraction and for maximum degree of sorption for each sample.

3. The maximum volume contractions at zero water concentration ranged from 42.6 cubic mm. per gram of dry material to 57.5 cubic mm. for the atmospheric roll-process samples, and from 69.2 cubic mm. per gram to 102.0 cubic mm. for the spray-process samples. These values correspond to degrees of sorption, expressed as percentage of the weight of the solids, respectively, as follows: 15.1 per cent, 18.5 per cent, 23.9 per cent and 36.3 per cent.

4. The volume contraction/degree of sorption ratio was found to be 2.88 ± .06 cubic mm./1 per cent sorption, which compares with the expected value of 3–4 cubic mm./1 per cent sorption. It is suggested that the reason for the low value for this ratio lies in the hydration of lactose in solution, with no accompanying volume contraction within the limits of concentration used here.

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THE DAIRY INDUSTRIAL FELLOWSHIP RESEARCH PROGRAM

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This article is a report of the Dairy Industrial Fellowship Research Program, sponsored jointly by the Dairy Industries Supply Association and the American Dairy Science Association. This report 1, offers a permanent record of the program and 2, gives to the dairy industry an account of the research undertaken and completed under the scholarship grants.

The program was formulated in 1929. At that time Professor R. B. Stoltz and other members of the Dairy Products Judging Committee of the American Dairy Science Association met with Messrs. Schantz, Everett, Breece and other representatives of the Dairy Industries Supply Association, Inc. to discuss the possibility of a joint program, sponsored by the two organizations, for furthering the student dairy products judging program. From this and subsequent meetings there evolved the plan of holding the National Dairy Products Judging Contest as a part of the Dairy Industries Exposition, under the joint sponsorship of the American Dairy Science Association and the Dairy Industries Supply Association, Inc.

The Dairy Industries Supply Association has furnished the financial aid and material assistance necessary for conducting the judging contest itself, and, in addition, has awarded annually, from 1930 to 1937 inclusive, six fellowship grants to six team members or alternates. For 1938 the number of grants was reduced from six to three. The fellowships originally carried a stipend of $750.00, which in 1934 was reduced to $600.00. The number and value of the fellowship grants are given in Table 1.

TABLE 1

Fellowship grants of the Dairy Industries Supply Association, Inc., 1930–1938

Year	Number of grants	Value of each	Total
1930	6	$750.00	$4,500.00
1931	6	750.00	4,500.00
1932	6	750.00	4,500.00
1933	6	750.00	4,500.00
1934	6	600.00	3,600.00
1935	6	600.00	3,600.00
1936	6	600.00	3,600.00
1937	6	600.00	3,600.00
1938	3	600.00	1,800.00
Total	51	.....	$34,200.00

These fellowships have made it possible each year for six students to continue their studies in dairying in the graduate school of another college

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for a 12-month period. The Industrial Fellow was thus required to matriculate in the graduate school as a candidate for the degree of Master of Science which necessitated the pursuit of subjects of a major and of a minor nature to dairying and the completion of a research problem closely allied to the dairy industry.

Up to 1934 the Industrial Fellowships were awarded to qualified students who had the highest standing in the judging of all dairy products. Qualification consisted in scholastic standing and in senior ranking at the college, thus enabling the Fellow to begin graduate work the following academic year. Since 1934, the awards have been made to the six leading colleges in the judging of all products. The Fellows were then selected from the members of the winning teams and alternates by the heads of the departments with the counsel of various staff members. The Fellows were permitted to choose the school in which to undertake graduate work from a list of schools represented in the current dairy products judging contest; the ranking individual having first choice and so on.

The problem subject, drawn up by the department of dairying in which the graduate study was undertaken, was submitted to committees representing the American Dairy Science Association and the Dairy Industries Supply Association, Tables 2 and 3, for comment and approval. At the

TABLE 2

Dairy products judging contest committees, 1926–1939, American Dairy Science Association

1926–27	1927–32	1932–34
R. B. Stoltz, Ch.	R. B. Stoltz, Ch.	R. B. Stoltz, Ch.
William White	William White	William White
M. Mortensen	H. W. Gregory	H. W. Gregory
G. D. Turnbow	G. D. Turnbow	P. A. Downs
H. W. Gregory	P. A. Downs	H. A. Bendixen
1934–36	**1936–37**	**1937–38**
H. W. Gregory, Ch.	H. W. Gregory, Ch.	H. W. Gregory, Ch.
William White	William White	William White
P. A. Downs	R. B. Stoltz	P. A. Downs
P. S. Lucas	P. A. Downs	M. J. Mack
R. B. Stoltz	R. W. Smith, Jr.	G. M. Trout
1938–39		
G. M. Trout, Ch.		
William White		
P. A. Downs		
M. J. Mack		
E. L. Fouts		

termination of the graduate period a full report of the research undertaken, suitable for publication in the various trade or scientific journals, was required. The acceptance of this report terminated the agreement between the college admitting the Fellow and the donors of the fellowship grant.

TABLE 3

Contest and fellowship committees, 1930–1939. Dairy Industries Supply Association, Inc.

1930

K. W. Schantz, Ch., K. W. Schantz Co.
Loomis Burrell, Cherry-Burrell Corp.
E. W. Chandler, The Creamery Package Mfg. Co.
Prof. H. F. Judkins, Representing International Assn. of Ice Cream Manufacturers
Dr. C. I. Corbin, Representing International Association of Milk Dealers
Dr. N. W. Hepburn, Representing American Butter Institute
Roberts Everett, Executive Vice President, Dairy Industries Supply Association, Inc.

1931

K. W. Schantz, Ch.
Loomis Burrell
G. E. Wallis, The Creamery Package Mfg. Co.
Prof. H. F. Judkins
Dr. C. I. Corbin
Dr. N. W. Hepburn
Roberts Everett

1932

K. W. Schantz, Ch.
Loomis Burrell
G. E. Wallis
Prof. H. F. Judkins
Dr. C. I. Corbin
Dr. N. W. Hepburn
Roberts Everett

1933

K. W. Schantz, Ch.
Loomis Burrell
G. E. Wallis
Prof. H. F. Judkins
Dr. C. I. Corbin
Dr. N. W. Hepburn
Roberts Everett

1934

Loomis Burrell, Ch.
G. E. Wallis
W. H. Breen, York Ice Machinery Corp.
Prof. H. F. Judkins
Dr. C. I. Corbin
Dr. N. W. Hepburn
Roberts Everett

1935

G. W. Putnam, Ch. The Creamery Package Mfg. Co.
Loomis Burrell
W. H. Breen
Dr. C. I. Corbin
Prof H. F. Judkins
Dr. C. W. Larson, Representing American Butter Institute
Roberts Everett

1936

G. W. Putnam, Ch.
Loomis Burrell
W. H. Breen
Dr. C. I. Corbin
Prof. H. F. Judkins
Dr. C. W. Larson
Roberts Everett

1937

L. B. Esmond, Ch., Northville Laboratories
G. E. Putnam
Loomis Burrell
G. F. Kroha, The Pfaudler Co.
T. J. Newbill, National Dairy & Food Bureau
Jarvis Williams, Jr., Standard Cap & Seal Corporation
Dr. N. W. Hepburn
Dr. C. I. Corbin
Prof. H. F. Judkins
Roberts Everett

1938

Dr. L. A. Rogers, Ch., Chief, Division of Dairy Research Labs., Bureau of Dairy Industry, U. S. Dept. Agr., Washington, D. C.
Dr. C. I. Corbin
Dr. N. W. Hepburn
Prof. H. F. Judkins
L. B. Esmond
Henry Rosenstein, Thomas W. Dunn Company
Norman Thomas, Sr., Joe Lowe Corporation
Roberts Everett

WINNERS OF FELLOWSHIPS

The colleges winning the industrial fellowships, the names of the Fellows, and the institutions to which they were assigned for research are presented in Table 4.

TABLE 4

Colleges winning Dairy Industries Supply Association Fellowships and recipients of the awards 1930–1938 inclusive

No.	College	Name of Fellow	Year
1	University of Arkansas	Niven, Charles F.	1934
2	Connecticut State College	Gibson, G. L.	1932
		Kosikowsky, Frank V.	1938
3	Cornell University	Tomlinson, Albert S.	1936
		Brereton, John G.	1937
		Ludington, Varnum D.	1938
4	University of Illinois	Ross, O. E.	1930
		Corbett, W. J.	1933
5	Iowa State College	Ause, D. H.	1931
		Brown, Howard W.	1934
		Ford, Mark	1935
		Wilson, Charles A.	1938
6	Kansas State College	Germann, Ralph F.	1930
		Hostetler, P.	1933
		Chilson, H.	1933
		Byers, E. L.	1934
7	Massachusetts State College	Shepard, Sidney	1932
		MacCurdy, Robert D.	1937
8	Michigan State College	Dowd, L. R.	1930
		Haradine, C. E.	1931
		Babel, Fred J.	1934
		Openlander, H. F.	1936
9	University of Minnesota	Sorensen, C. M.	1933
		Josephson, Donald	1934
		Freeman, Robert	1935
		Rivers, Philip	1936
		Naylor, Brooks	1937
10	Mississippi State College	Quinn, J. D.	1930
		Whitfield, B. H.	1931
		Long, John H.	1932
		Carithers, R. L.	1933
		White, H. W.	1935
		Harris, William C.	1937
11	University of Nebraska	Kelley, Martin F.	1930
		Meredith, P. W.	1932
		Warner, James	1935
		Larson, Richard A.	1936
12	Ohio State University	Brockschmidt, J. H.	1931
		Homberger, R. E.	1931
		Charles, Donald A.	1932
		Slatter, Walter L.	1934
		Smith, Hiram P.	1935
		Adams, Joseph	1936
		Roahen, Dan C.	1937
13	Ontario Agricultural College	Goodwillie, D. B.	1930
14	Purdue University	Cantley, R. W.	1932
15	South Dakota State College	Spicer, Delmar	1934
		Henry, Dave	1937
16	University of Tennessee	Flake, J. C.	1935
		Robert, M. William	1936
17	University of Vermont	Leech, H.	1931

Here it will be noted that of the 17 colleges winning one or more fellowships, Ohio leads the list with seven, closely followed by Mississippi with six, and Minnesota with five. Iowa, Kansas, Michigan and Nebraska have each won four fellowships. It should be mentioned here that some teams and individuals from several schools, including those above mentioned, had sufficient high standing in judging to merit consideration, but were not qualified. Hence, in Table 4 are listed only the schools which, and individuals who, were finally awarded the grants.

ASSIGNMENT OF FELLOWS

Choice of schools in which to pursue graduate work was made in the order of the respective standings of the winning teams, or individuals, Table 5. No two Fellows were permitted to pursue graduate work at the

TABLE 5

Winners of Dairy Industries Supply Association Fellowships and the colleges to which they were assigned for research

Name	From	Individual* placing	Assigned to
	1930		
1. Ross, O. E.	Illinois	1st	Iowa
2. Goodwillie, D. B.	Ontario	2nd	Michigan
3. Quinn, J. D.	Mississippi	3rd	Ohio
4. Germann, Ralph F.	Kansas	4th	Pennsylvania
5. Dowd, L. R.	Michigan	6th	Purdue
6. Kelley, Martin F.	Nebraska	8th	Wisconsin
	1931		
1. Ause, D. H.	Iowa	1st	Minnesota
2. Homberger, R. E.	Ohio	3rd	California
3. Haradine, C. E.	Michigan	4th	Illinois
4. Whitfield, B. H.	Mississippi	5th	Nebraska
5. Leach, H.	Vermont	9th	Kansas
6. Brockschmidt, J. H.	Ohio	10th	Massachusetts
	1932		
1. Long, John H.	Mississippi	1st	Michigan
2. Meredith, P. W.	Nebraska	2nd	Ohio
3. Cantley, R. W.	Purdue	3rd	Cornell
4. Gibson, G. L.	Connecticut	5th	Illinois
5. Shepard, Sidney	Massachusetts	10th	Iowa
6. Charles, Donald A.	Ohio	11th	Wisconsin
	1933		
1. Corbett, W. J.	Illinois	1st	Wisconsin
2. Hostetler, P.	Kansas	2nd	Iowa
3. Chilson, H.	Kansas	3rd	Cornell
4. Carithers, R. L.	Mississippi	4th	Minnesota
5. Sorensen, C. M.	Minnesota	5th	Purdue
6. Spicer, Delmar	South Dakota	6th	Ohio

same institution the same year; nor could a Fellow continue work at the same institution from which he graduated. Consequently, the research under these grants has been carried out in a wide selection of colleges, a

TABLE 5 (Continued)

Name	From	Team* placing	Assigned to
	1934		
1. Slatter, Walter L.	Ohio	1st	Iowa
2. Josephson, Donald	Minnesota	2nd	Pennsylvania
3. Byers, E. L.	Kansas	3rd	Wisconsin
4. Babel, Fred J.	Michigan	4th	Purdue
5. Brown, Howard W.	Iowa	5th	Illinois
6. Niven, Charles F.	Arkansas	6th	Cornell
	1935		
1. White, H. W.	Mississippi	1st	Ohio
2. Flake, J. C.	Tennessee	3rd	Purdue
3. Smith, Hiram P.	Ohio	4th	Illinois
4. Ford, Mark	Iowa	5th	Cornell
5. Freeman, Robert	Minnesota	6th	Connecticut
6. Warner, James N.	Nebraska	7th	Iowa
	1936		
1. Adams, Joseph	Ohio	1st	Purdue
2. Tomlinson, Albert	Cornell	3rd	Wisconsin
3. Larson, Richard	Nebraska	4th	Michigan
4. Rivers, Philip	Minnesota	5th	Pennsylvania
5. Roberts, M. William	Tennessee	6th	Minnesota
6. Openlander, H. F.	Michigan	7th	Ohio
	1937		
1. Roahen, Dan C.	Ohio	1st	Wisconsin
2. Harris, William C.	Mississippi	2nd	Iowa
3. MacCurdy, Robert D.	Massachusetts	3rd	Michigan
4. Naylor, Brooks	Minnesota	5th	Cornell
5. Brereton, John G.	Cornell	6th	Minnesota
6. Henry, Dave	S. Dakota	7th	Ohio
	1938		
1. Ludington, Varnum D.	Cornell	1st	
2. Wilson, Charles Ashley	Iowa	2nd	(To be assigned)
3. Kosikowsky, Frank V.	Connecticut	3rd	

* The fellowships were awarded from 1930 to 1933 inclusive, to eligible individuals on the basis of their proficiency in judging; since then, to members of the leading teams.

total of 14, as shown in Table 6. A total of 20 different schools have benefited one or more years by these grants. A number of schools have won a fellowship and have been assigned a Fellow from another institution the same year, thus two-fold benefits were received.

Three state colleges or universities, namely, Iowa, Ohio, and Wisconsin, have each been assigned six Fellows. Cornell and Purdue each have been assigned five, while Illinois, Michigan and Minnesota each have been assigned four. Pennsylvania has been assigned three, while California, Connecticut, Kansas, Massachusetts and Nebraska each have been assigned one Fellow. The three Dairy Industrial Fellows of 1938 remain to be assigned for research. Nine colleges or universities, Cornell, Iowa, Illinois, Michigan, Minnesota, Ohio, Pennsylvania, Purdue and Wisconsin, have thus directed 89.58 per cent of the research projects under the Dairy Industrial Fellowships.

TABLE 6

No.	College	Fellowships won by team or individuals†		Fellows assigned for graduate work‡	
		No.	*%*	*No.*	*%*
1.	University of Arkansas	1	1.96	0	0.00
2.	University of California	0	0.00	1	2.08
3.	Connecticut State	2	3.92	1	2.08
4.	Cornell University	3	5.88	5	10.42
5.	Iowa State	4	7.84	6	12.50
6.	University of Illinois	2	3.92	4	8.33
7.	Kansas State	4	7.84	1	2.08
8.	Massachusetts State	2	3.92	1	2.08
9.	Michigan State	4	7.84	4	8.33
10.	University of Minnesota	5	9.80	4	8.33
11.	Mississippi State	6	11.76	0	0.00
12.	University of Nebraska	4	7.84	1	2.08
13.	Ohio State University	7	13.73	6	12.50
14.	Ontario Agricultural	1	1.96	0	0.00
15.	Pennsylvania State	0	0.00	3	6.25
16.	Purdue University	1	1.96	5	10.42
17.	South Dakota State	2	3.92	0	0.00
18.	University of Tennessee	2	3.92	0	0.00
19.	University of Vermont	1	1.96	0	0.00
20.	University of Wisconsin	0	0.00	6	12.50
	Total fellowships	51	99.97	48	99.98
	Total schools	17		14	

† Fellowships were awarded to eligible individuals 1930–1933 inclusive, then to ranking teams.

‡ Fellows 1938 to be assigned.

PROBLEM ASSIGNMENT

To classify the research problems assigned and undertaken by the Industrial Fellows has been difficult because of the very nature of some of the problems. In many cases the problem applied to several products. An attempt was made, however, to classify them on the basis of some dairy product, realizing that other classifications, such as tests, methods of manufacturing, distribution, bacteriology and so on might have been used. The distribution is shown in Table 7. According to the classification employed, the research undertaken has dealt with some phase of butter, buttermilk, cheese, condensed milk, milk or ice cream. Thirty-one and three-tenths per cent of the projects have been closely associated with milk; 31.2 with ice cream; 16.6 with butter; 10.4 with cheese; and 4.2 per cent each with buttermilk and with condensed milk. The specific title of the project problems may be noted from the list of publications in Table 8.

PUBLICATIONS

The manuscripts, summarizing the results of one year's research on the specific problems, have been published entire or in part in one of several trade or scientific journals. These are listed in Table 8 by years, giving the names of the author or authors, title and where published. Recently a plan

TABLE 7

Distribution of research problems of association Fellows by years, 1930 to 1937 inclusive

Product*	1930	1931	1932	1933	1934	1935	1936	1937	Total	%
Butter		1	1		1	1	2	2	8	16.6
Buttermilk	1					1			2	4.2
Cheese	1			2	1			1	5	10.4
Condensed milk		1	1						2	4.2
Milk	2	2	3	3	1	2	1	2	16	33.3
Ice cream	2	2	1	1	3	2	3	1	15	31.2
Total	6	6	6	6	6	6	6	6	48	99.9

* Some projects may have applied to one or more products, for example, (1) the use of dry milk of different manufacture in ice cream or (2) the resazurin test in determining the quality of milk and ice cream. For the sake of clarity the problem was tabulated as far as possible with the product chiefly concerned in the research.

has been effected whereby the article may first be submitted for publication to a scientific journal, afterwards rewritten in popularized form for trade journal publication. The manuscripts resulting from the first five years of study have been published in the trade journals. The abstracting service of the various scientific journals has made available much of this material to the research field.

TABLE 8

Publications and research projects of the Dairy Industries Supply Association Fellows, by years, 1930 to present date

1930

1. Ross O. E. Why Does a Tallowy Flavor Develop in Strawberry Ice Cream? Ice Cream Trade Journal, July, 1933.
2. Goodwillie, D. B., and Trout, G. M. Factors Other than Bacteria That Influence the Body and Flavor of Granuled Buttermilk. The Milk Dealer, February and March, 1933.
3. Quinn, J. D., and Burgwald, L. H. High Short Holding and Low Long Holding Pasteurization of Milk. Milk Plant Monthly, February, 1933.
4. Bradley, * H. H., and Dahle, C. D. How Freezing and Hardening Affects the Texture of Ice Cream. The Ice Cream Trade Journal, November, 1933.
   * Completed work begun by Ralph Germann, Fellow, 1930.
5. Dowd, L. R. Some Factors Affecting the Efficiency of Pasteurization of Milk. American Creamery and Poultry Produce Review, January, 1935.
6. Kelly, Martin F., and Price, Walter V. A Study of the Manufacture of Cottage Cheese. National Butter and Cheese Journal, February, 1933.

1931

1. Ause, O. H., and Macy, H. The Relation of Oospora Lactis to the Keeping Quality of Butter. American Creamery and Poultry Produce Review, December, 1934.
2. Homberger, R. E., and Cole, W. C. Factors Affecting Lactose Crystallization as Related to Sandy Ice Cream. The Ice Cream Review, November, 1933.
3. Haradine, C. E. Inversion of Sucrose in the Manufacture of Sweetened Condensed Milk, and its Effect upon Color of Finished Product. National Butter and Cheese Journal, October, 1933.
4. Whitfield, Benjamin H., Davis, H. P., and Downs, P. A. The Effect of Milk upon Metals and Metals upon Milk. The Milk Dealer, November and December, 1934, and January, 1935.
5. Leach, H. J., and Martin, W. H. The Effect of a Surface Cooler on Flavor, Cream Line and Evaporation Loss. American Creamery and Poultry Produce Review, November, 1933.
6. Brockschmidt, J. H., Mack, M. J., and Frandsen, J. H. How to Make High Butterfat Ice Cream; A Study of the Factors Involved in Making the Richer Type of Product. Ice Cream Field, December, 1933, and January, 1934.

1932

1. LONG, W. JOHN, HUFFMAN, C. F., AND DUNCAN, C. W. A Study of the Vitamin D Requirements of Calves When Natural Milk Furnished the Sole Source of the Antirachitic Factor. Milk Plant Monthly, July, 1936.
2. MEREDITH, PERRY W., AND STOLTZ, R. B. Bottled Concentrated Milk, A Lower Priced Fresh Milk for the Consumer. The Milk Dealer, February, 1935.
3. CANTLEY, ROBERT W. Comparison of Skimmed Milk Powder Media with Standard Nutrient Agar for Bacterial Counts on Milk. Ice Cream Field, May and June, 1935.
4. GIBSON, G. L. Sandiness: Its Causes and Prevention. Ice Cream Field, May and June, 1935.
5. SHEPARD, SIDNEY, AND OLSON, H. C. The Relationship Between Changes in the Number of Bacteria and in the Scores of Butter Held at 32° F. National Butter and Cheese Journal, September, 1935.
6. CHARLES, D. A., AND SOMMER, H. H. Causes and Practical Methods for Control of Sedimentation in Homogenized Milk. Milk Plant Monthly, April, 1935.

1933

1. CORBETT, W. J., FRAZIER, W. J., AND PRICE, W. V. A Gas Defect of Cream Cheese. The Milk Dealer, December, 1935.
2. HOSTETLER, PIUS H. Effects of Preservatives on Results of Fat Test Studies. Confectionery and Ice Cream World, August, 1936.
3. CHILSON, WILLIAM H. A Study of the Oxidized Flavors of Market Milk. Milk Plant Monthly, November and December, 1935.
4. CARITHERS, ROBERT L., AND COMBS, W. B. Drum vs. Spray Process Dry Milk in Ice Cream. The Ice Cream Review, March, 1936.
5. SORENSON, C. M. Studies on Milk Mold Oospora Lactis. American Creamery and Poultry Produce Review, February, 1936.
6. SPICER, W. DELMAR, AND BURGWALD, L. H. Use of Hydrogen Ion Determination on Young Cheese in Predicting Acid Development in Cheddar Cheese During Storage. National Butter and Cheese Journal, November, 1935.

1934

1. SLATTER, WALTER L. Changes in the Acetylmethylcarbinol Plus Diacetyl Content of Butter. National Butter and Cheese Journal, October and November, 1936.
2. DAHLE, C. D., AND JOSEPHSON, D. V. The Importance of the Fat Globule Membrane in the Freezing of Ice Cream. The Ice Cream Review, January, 1937.
3. BYERS, E. L., AND PRICE, WALTER V. Influence of Salt on the Composition and Quality of Brick Cheese. National Butter and Cheese Journal, July, 1937.
4. BABEL, F. J. Significance of Laboratory Tests in the Control of Ice Cream. The Ice Cream Trade Journal, September, 1936.
5. BROWN, W. H. This Matter of Mix. Ice Cream Field, July and August, 1937.
6. SHERMAN, J. M., AND NIVENS, CHARLES F. The Hemolytic Streptococci of Milk. Journal of Infectious Diseases, March and April, 1938.

1935

1. WHITE, H. W. Factors Affecting the Quality of Churned Buttermilk. Unpublished.
2. FLAKE, J. C. Some Causes for the Deterioration in 10 Days at 15.5° C. of Salted Butter Made from Sour Cream. Flake, J. C., and Parfitt, E. H. JOURNAL OF DAIRY SCIENCE, September, 1938.
3. SMITH, HIRAM P. Variations in Color, Flavor, and Body Types of Ice Cream as Affecting Consumer Preference. Confectionery and Ice Cream World, February, 1938.
4. KNAYSI, GEORGE, AND FORD, MARK. A Method of Counting Viable Bacteria in Milk by Means of Microscope. JOURNAL OF DAIRY SCIENCE, March, 1938.
5. FREEMAN, ROBERT. Sonic Vibration as a Means of Preparing Ice Cream Mixes. Unpublished.
6. WARNER, JAMES N. The Use of Resazurin in Determining the Sanitary Qualities of Milk and Ice Cream. Dairy World, February, 1938.

1936

1. ADAMS, JOSEPH, AND PARFITT, E. H. Some Factors Influencing the Amount of Mold Mycelia in Butter. JOURNAL OF DAIRY SCIENCE, May, 1939.

2. TOMLINSON, ALBERT S. Enzymes in the Development of Oxidized Flavor in Milk. Unpublished.
3. LARSON, RICHARD A. Relationship of Hydrometer Readings to the Composition and Some Physical Properties of Pan Condensed Ice Cream Mixes. Unpublished.
4. RIVERS, PHILIP. Factors Affecting the Stability and Properties of Ice Cream Mix with Special Reference to Those Frozen in the Continuous Freezer. Unpublished.
5. ROBERTS, WILLIAM M. Experiments with High Temperature Pasteurization of Cream for Buttermaking. Unpublished.
6. OPENLANDER, HERMAN. The Use of Plain Frozen Condensed Milk in Ice Cream. Unpublished.

INFLUENCE OF GRADUATE TRAINING ON VOCATION OF FELLOWS

A study was made in the spring of 1938 of the vocations of the industrial Fellows and of the other team members and alternates to ascertain the influence of further dairy training upon the vocation of the student.

The percentage distribution of the vocations in which the team members, alternates and Fellows, from the 29 colleges competing in the national dairy products judging contest from 1930 to 1937 inclusive, were engaged at the time the study was made, is presented in Table 9. Inasmuch as six of the Fellows at that time were yet classified as undergraduate and that six other Fellows were engaged in research studies towards the master's degree, a total of 12, out of the total number of 48, it was difficult to classify their vocation other than as undergraduate and research. The percentage of Fellows graduated and engaged in the profession of their training is significantly higher, 45.8 per cent compared to 38.97 per cent, than those not having had the opportunity for further study. This high yield speaks well for the value of the Industrial Fellowships in furthering the training of men for the industry.

TABLE 9

Percentage distribution of all dairy products judging team members and alternates from 1930 to 1937, inclusive, according to their present occupations

Occupation	Association Fellows		All team members and alternates	
	No.	%	No.	%
1. Dairy plant (mgr., supt., res., lab., etc.)	22	45.8	191	38.97
2. Inspection and extension (federal, state, or city inspection, Co. Agt., 4-H Club agent, D.H.I.A., etc.)	2	4.2	54	11.02
3. Owner of plant (wholly or in part)	1	2.1	16	3.26
4. Teaching and research* or assisting (college and U.S.D.A.)	17	35.4	70	14.29
5. Undergraduate	6	12.5	57	11.63
6. Dairy farming	–		15	3.06
7. Vocational education, high school	–		21	4.28
8. Miscellaneous (unknown, insurance, automobile, etc.)	–		66	13.46
Total	48	100.0	490	99.97

* Including the six 1936 Fellows, who were engaged on their assigned problem when the data were compiled.

From this table it may be noted that approximately 39.0 per cent of all contestants and alternates, nearly 500, are plant owners, plant managers, superintendents, or commercial researchers. About 14.0 per cent are employed by colleges and the United States Department of Agriculture as teachers and researchers.

VALUE OF RESEARCH TO THE INDUSTRY

When the 1938 Dairy Industrial Fellows will have completed their graduate problem at the close of the academic year of 1939–1940, 51 selected men will have received graduate training in dairying and will have completed 51 dairy research projects. These men have profited personally from the opportunities afforded them through the Dairy Industrial Fellowships to continue their studies and to broaden their acquaintances. Likewise, the fund of scientific dairy information has materially increased while the concepts concerning dairy problems have been enlarged. Yet, the personal and specific benefits derived are insignificant in comparison to the inestimable value of the joint Dairy Industrial Research Program to the colleges, to the American Dairy Science Association, to the Dairy Industries Supply Association and to the dairy industry itself. Now in its ninth year, the program, as a part of the jointly sponsored students' National Dairy Products Judging Contest, has played a major role in dairy education, first, in furnishing incentives to the undergraduate and second, in making possible further dairy training to a selected group of dairy students.

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Bennett, F. W.
Bird, E. W.
Burgwald, L. H.
Burri, R.
Brueckner, H. J.
Burke, A. D.
Bushnell, L. D.

Cannon, C. Y.
Carpenter, D. C.
Cave, H. W.
Clevenger, W. L.
Cole, W. C.
Copeland, L.
Coulter, S. T.
Cunningham, O. C.
Cunningham, W. S.

Dahlberg, A. C.
Darnell, A. L.
Doan, F. J.
Dorsey, L. M.
Downs, P. A.

England, C. W.
Erb, J. H.
Espe, D. L.

Fabian, F. W.
Frayer, J. M.
Frazier, W. C.
Fuller, J. M.

Garrett, O. F.
Geipl, A. J.
Golding, N. S.
Goss, E. F.
Greenbank, G. R.
Gullickson, T. W.
Guthrie, E. S.

Hansen, Arne
Herrington, B. L.
Herzer, F. H.
Holdaway, C. W.
Horrall, B. E.
Huffman, C. F.

Irwin, O. R.

Jacobson, C. O.
Jensen, Chris
Josephson, D. V.

Keith, J. I.
Knight, D.
Krauss, W. E.

LaMaster, J. P.
Leighton, A.
Lindquist, H. G.
Locke, R. B.
Lucas, P. S.
Lush, J. L.

Mack, M. J.
Macy, H.
Mann, A. I.
Marquardt, J. C.
Martin, W. H.
Mead, S. W.
Moore, L. A.
Morris, A. J.
Mueller, W. S.

Nelson, D. H.
Nelson, J. A.

Overman, O. R.

Palmer, C. C.
Parfitt, E. H.
Petersen, W. E.
Price, W. V.

Reid, W. H. E.
Richardson, G. A.
Riddell, W. H.

Schultz, E. N.
Sommer, H. H.
Stark, C. N.
Swope, W. D.

Tarassuk, N. P.
Theophilus, D. R.
Thomsen, L. C.
Thurston, L. M.
Totman, C. C.
Trout, G. M.
Tuckey, S. L.

Webb, B. H.
Weckel, K. G.
White, G. C.
Wilbur, J. W.
Wilster, G.
Wylie, C. E.

Yale, M. W.

JOURNALS

American Creamery and Poultry Produce Review
American Journal of Diseases of Children
American Journal of Physiology
American Journal of Public Health
Archives of Pediatrics

Biochemical Journal
Biochemische Zeitschrift

Canadian Dairy and Ice Cream Journal
Canadian Public Health Journal
Certified Milk
Cornell Veterinarian

Dairy Industries
Deutsche Molkerei Zeitung

Endocrinology

Food Industries
Food Manufacture
Food Research

Guernsey Breeders Journal
Ice and Refrigeration
Ice Cream Field
Ice Cream Industry
Ice Cream Review
Ice Cream Trade Journal
Industrial and Engineering Chemistry

Jersey Bulletin
Journal of Agricultural Research
Journal of Agricultural Science
Journal of American Chemical Society
Journal of American Veterinary Medicine Association
Journal of Bacteriology
Journal of Biological Chemistry
Journal of Dairy Research
Journal of Dairy Science
Journal of Experimental Medicine
Journal of General Physiology
Journal of Heredity
Journal of Genetics
Journal of Infectious Diseases
Journal of London Chemical Society
Journal of Milk Technology
Journal of Nutrition
Journal of Pathology and Bacteriology
Journal of Physical Chemistry
Journal of Physiology

Kaeseindustrie
Kolloid-Zeitschrift

Lancet
Le Lait

Milchwirtschaftliche Forschungen
Milchwirtschaftliche Zeitung
Milk Dealer
Milk Industry
Milk Plant Monthly
Molkerei Zeitung

National Butter and Cheese Journal

Pacific Dairy Review
Proceedings of Society of Animal Production
Proceedings of Society of Experimental Biology and Medicine

Scientific Agriculture

Tierernährung
Tierzüchter
Trudy Vologodskogo Molochnogo Institut

Zeitschrift für Infektionskrankheiten Parasitäre Krankheiten und Hygiene der Haustiere
Zeitschrift für Physikalische Chemie, Abt. A and B
Zeitschrift für Untersuchtung der Lebensmittel
Zeitschrift für Züchtung. Reihe B. Tierzuchtung und Zuchtungbiologie
Zentralblatt für Bacteriologie
Züchtungskunde

SPECIAL PUBLICATIONS

Federal Dairying and Bacteriological Establishment, Liebefeld, Berne, Switzerland

International Association of Ice Cream Manufacturers
International Association of Milk Dealers

National Institute for Research in Dairying, Reading, England
New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BOOK REVIEWS

360. Standard Methods for the Examination of Dairy Products. American Public Health Association, 50 West 50th Street, New York, N. Y., and Association of Official Agricultural Chemists, Box 290, Pennsylvania Avenue Station, Washington, D. C. Price $2.50.

This is the seventh edition of the report entitled *Standard Methods for the Examination of Milk*, a publication so well known to the readers of the JOURNAL OF DAIRY SCIENCE that little description is necessary. However, in the present edition methods are included for the examination of ice cream and butter and the title has been changed from one referring to milk and cream only to one including dairy products in general. Other important changes in the seventh edition are; the introduction of methods for the bioassay of vitamin D milk, and improved formula for standard agar, and other changes in the bacteriological section which should help standardize the agar plate technique. Proposed phosphatase methods for the determination of pasteurization are appended. T.S.S.

361. Dairy Science. W. E. PETERSEN. J. B. Lippincott Co. 679 pages, illustrated.

This book, designed primarily as a text for college students majoring in dairy production, presents a rather comprehensive treatment of the field of dairy production and technology. The subject matter is presented in 53 chapters under the following chapter headings.

1. The History of Dairying, 2. Economics of Milk Production, 3. Milk Consumption, 4. Economics of Market Milk, 5. Economics of the Butter Industry, 6. Economics of the Cheese Industry, 7. Economic Phases of the Concentrated Milk Products, 8. Economics of the Ice Cream Industry, 9. Economic Phases of Milk By-products, 10. Origin, Development, and Classification of Dairy Cattle, 11. The Holstein-Friesian, 12. The Jersey, 13. The Guernsey, 14. The Ayrshire, 15. The Brown Swiss, 16. The Milking Shorthorn, 17. The Red Polled, 18. The Lesser Breeds, 19. Types of Dairy Farming and Breed Selection, 20. Selecting the Individual Cow, 21. Fundamental Considerations of Heredity, 22. Measures of the Genetic Makeup, 23. Known Inherited Characteristics in Dairy Cattle, 24. Systems of Breeding, 25. Selection and Care of the Herd Sire, 26. The Purebred Business, 27. Growth and Development, 28. Calf Raising, 29. Raising the Heifer from Weaning to Calving Time, 30. The Cow's Udder—Its Structure and Development, 31. The Physiology of Milk Secretion, 32. Factors Influencing the Quantity and Quality of Milk, 33. Management of Dairy Cows, 34. The Milking Machine, 35. Record Keeping, 36. Efficiency and Cost of Milk Pro-

duction, 37. Common Diseases of Dairy Cows, 38. Dairy Barns, 39. Barnyard Manure, 40. Feeding Dairy Cattle, 41. Common Feeds: Characteristics and Treatment, 42. Feeding Dairy Cows in the Barn, 43. Feeding Cows on Pasture, 44. Chemical Constituents of Milk, 45. Physical and Chemical Properties of Milk, 46. Dairy Microbiology: Bacteria, Yeasts, and Molds, 47. Common Tests of Milk and Cream, 48. The More Common Dairy Processes, 49. Market Milk, 50. Butter, 51. Cheese, 52. Condensed and Dried Milk, 53. Ice Cream and other Dairy Products.

The material in those chapters dealing with specific production problems is dealt with exhaustively while that of those pertaining to other phases of the industry is of a general nature.

This book is well written and generously illustrated. A list of selected references for each chapter and questions covering the material presented in each chapter are helpful additions to the appendix. T.S.S.

362. Dairy Science Abstracts. Imperial Bureau of Dairy Science, Shinfield, Reading, England.

The Imperial Bureau of Dairy Science announces this new abstracting service in the form of Dairy Science Abstracts Vol. 1, No. 1, May 1939. The specimen copy received indicates a comprehensive coverage of the current dairy science literature abstracted under the general headings, *Husbandry, Technology, Control and Standards, Economics, Physiology, Bacteriology and Mycology, Chemistry and Physics, and Miscellaneous.* Published quarterly, annual subscription rate for the United States of America including postage is 25/–. T.S.S.

BACTERIOLOGY

363. Use of Agar Slants in Determining the Sanitary Quality of Milk. G. J. Hucker and W. C. Haynes, New York State Agr. Exp. Sta., Geneva, N. Y. Am. J. Pub. Health, *29:* 6, 651, 1939.

The Burri slant procedure is described which consists in spreading 0.001 cc. of milk with a standardized loop over the dry surface of a 2 per cent agar slant. The method is simple and of practical value for use in controlling the sanitary quality of milk and other products. M.W.Y.

364. The Operation of the Bacteriological Laboratory for Dairy Plants. C. S. Mudge. Calif. Exper. Sta. Circular, *310:* 37, June, 1938.

This circular is designed to supplement the Standard Methods of Milk Analysis by giving such directions as are necessary for the dairy laboratory technician who has not had the advantage of college grade training. Included are a brief description of bacteria, the arrangement of the laboratory, a list of necessary equipment with directions for best results with it, direc-

tions for making media, standardization of pH, and instructions for operating the laboratory in all the steps from collecting the sample through plating, incubation, and counting. The manipulations in making the direct microscopic count are described.

Of unusual interest is a section devoted to the proper use of the microscope and a discussion of critical illumination in microscopy. E.L.J.

BREEDING

365. The Relationship of Environment to Selection. L. M. WINTERS, Univ. of Minn. Proc. Am. Soc. Animal Prod., *31:* 278–283. 1938.

From a consideration of the effect of environment on the expression of inheritance it is suggested in proving dairy cattle that the purpose may be defeated under such artificial conditions as prevail in Advanced Registry or show herd performance. G.C.W.

366. Relation of Regression to Selection. W. W. YAPP, Univ. of Ill. Proc. Am. Soc. Animal Prod., *31:* 272–277. 1938.

The prevailing conceptions to account for regression are mentioned, data on the university Holstein herd is presented, and consideration is given to the theory as applied to dairy cattle breeding. G.C.W.

367. Conference on Artificial Insemination.—six papers. Proc. Am. Soc. Animal Prod., *31:* 223–259. 1938.

Includes six papers on recent experiences in the United States and in England on various phases of the subject. G.C.W.

368. Estrus, Ovulation, and Artificial Insemination in Dairy Cattle. G. M. WERNER, L. E. CASIDA, AND I. W. RUPEL, Univ. of Wis. Proc. Am. Soc. Animal Prod., *31:* 54–57. 1938.

Observations were made A.M. and P.M. on evidence of heat in a group of 35 heifers on pasture. Examination for follicles showed none to be ruptured while in heat; 17 to be ruptured by the end of the first day following heat; 19 more ruptured by the end of the second day; and the final 3 between the end of the second and 2½ days following the close of estrum. Reference was also made to experiences with artificial insemination. G.C.W.

369. Nicking in Dairy Cattle. E. E. HEIZER, M. C. HERVEY, G. R. BARRETT, AND G. W. BRANDT, Ohio State Univ. Proc. Am. Soc. Animal Prod., *31:* 67–72. 1938.

To study the theory of nicking, the daughters of sires in a large Ayrshire herd, a large Guernsey herd, and a large Holstein herd were grouped according to the family, or sire relationship, of their dams. Distinct evi-

dence of nicking seemed to be indicated and it was suggested that this is due to complementary effects of genes. G.C.W.

BUTTER

370. Observation on Roll-less Churns. O. F. HUNZIKER, La Grange, Ill. Nat. Butter and Cheese J., *30:* 7, 12, 1939.

The operation of one roll-less churn has been observed since June, 1938. Compared with a roll churn made by the same manufacturer it was found that the roll-less churn shortened the churning period by 6 minutes without decreasing the exhaustiveness of churning; shortened the working period 2 minutes; distributed moisture and salt as uniformly; produced as good body; reduced the yeast and mold count slightly but consistently; worked large and small churnings effectively; and was surprisingly efficient in reworking high moisture churnings. W.V.P.

371. Butter Storage. J. L. PARSONS, W. H. MARTIN, AND D. L. MARTIN, Kansas Agr. Exp. Sta., Manhattan, Kansas. Nat. Butter and Cheese J., *30:* 5, 16, 1939, and 6, 50, 1939.

Storage stocks of butter usually increase in summer and decrease in winter months but the quantity in storage is a small proportion of the annual production. Butter production, consumer demand and the previous year's profit on stored butter affect the volume of butter stored.

Storage charges in Chicago for butter valued at 25 cents per pound equal $0.00359 for the first month and $0.00244 per pound for each succeeding month. Hedging charges and tax increase the cost. Price changes chiefly determine profits and losses in storing butter. Factors affecting butter prices are listed and discussed to show how operators can protect their investment. W.V.P.

372. Application of the Phosphatase Test to Creamery Butter. G. W. SHADWICK, JR., AND M. E. PARKER, Beatrice Creamery Co., Chicago, Ill. Am. J. Pub. Health, *29:* 5, 482, 1939.

A series of experiments was made upon sour cream "flashed" at different temperatures using a laboratory pasteurizer. The results indicate that a temperature of 185° F. or higher will give negative phosphatase reactions both with the cream and the butter freshly made from it. Some indications of possible phenol production by bacterial activity in butter samples subject to the keeping quality test of holding at 70° F. for 8 days were observed. The authors point out that due to factors which may stimulate phenol production in butter during storage, caution should be exercised in interpreting a positive phosphatase test as indicative of the inadequate pasteurization of the cream used in its manufacture. M.W.Y.

373. Studies of Musty Flavor Outbreaks. HAROLD MACY. Am. Prod. Rev., *87:* 20, 514–515, Mar., 1939.

This article is of preliminary work being done on a frequently reported defect found in some butter samples, known as "mustiness," but more nearly representing a malty flavor. The defect was reproduced by inoculating experimental batches of cream with bacteria closely resembling *Streptococcus lactis var. multigenes.* Suggested control of this type bacteria includes grading out milk and cream showing the flavor, proper care of utensils on the farm, holding cream cold before pasteurization and pasteurization at 160° F. or higher for thirty minutes. P.S.L.

374. Methods of Testing Buttermilk. E. W. BIRD. Am. Prod. Rev., *87:* 16, 374–377, Feb., 1939.

The author describes methods in use in testing buttermilk, their limitation, the characteristics of the fatty-like materials found in buttermilk, and calculation of fat losses by formulae. He emphasizes that buttermilk fat test is not so important *per se*, but that fat loss per 100 pounds fat placed in the churn is very important; that the buttermaker's judgment should be regulated by the particular buttermilk test used; and that cream test affects vitally the churning loss. P.S.L.

CHEESE

375. Factors That Influence Cheesemaking. W. S. ARBUCKLE, Univ. of Missouri, Columbia, Mo. Nat. Butter and Cheese J., *30:* 7, 38, 1939.

A review is given of the characteristic properties and functions of the important constituents of milk in cheese-making. The influence of pasteurization, mastitis and special treatments of milk, curd and cheese on quality of cheese are mentioned briefly. W.V.P.

376. Cut Cottage Cheese Returns 90 Per Cent. ANONYMOUS. Milk Dealer, *28:* 8, 39, May, 1939.

Foremost Dairies, Birmingham, Alabama, have been able to cut down on their returns of cottage cheese from the stores 90 per cent by exposing to ultra rays the cheese, the package, the lid and the surrounding air during the packing process. C.J.B.

CHEMISTRY

377. pH—What It Means. S. T. COULTER, Univ. of Minn., St. Paul, Minn. Nat. Butter and Cheese J., *30:* 6, 18, 1939.

Active acidity or alkalinity is measured by pH while total acidity or alkalinity is measured by titration. The activity of acids (or alkalies) depends on their tendency in solution to dissociate into hydrogen (or hy-

droxyl) ions. Strong active acids like hydrochloric dissociate completely while weak acids like lactic undergo relatively slight dissociation. Even water dissociates at room temperatures to give $\frac{1}{10{,}000{,}000}$ grams of hydrogen ions per liter. For convenience this concentration is converted to pH by the formula :— $pH = \log 10 \frac{1}{\text{hydrogen ion concentration}}$. The pH of water or true neutrality therefore, is 7.0. A scale shows pH values and hydrogen ion concentrations corresponding to the end point of phenolphthalein titration, iso-electric point of casein, various concentrations of acids and alkalies and acidities of common dairy products. Hydrogen ion concentration rather than titratable acidity influences many chemical changes in dairy products and the actions of enzymes and bacteria. Measurements of pH cannot always be used instead of titratable acidity determinations.

W.V.P.

378. Separation of Lactose and Soluble Proteins of Whey by Alcohol Extraction. ABRAHAM LEVITON AND ALAN LEIGHTON. Ind. Eng. Chem., *30:* 11, 1305–1311,1938.

A new process is described for the separation of the constituents of sweet soluble spray-dried whey powder by extraction with 70 per cent or 95 per cent alcohol. The whey powder is first treated with sufficient alcohol to wet it, the paste is then mixed with additional alcohol, and the resulting solution rapidly filtered. The protein, being insoluble in the solvent, is recovered as a precipitate and dried. The fraction contains approximately 50 per cent water-soluble and heat-coagulable whey protein, 15 per cent ash, and 35 per cent lactose. It possesses high whipping properties. After removal of the protein precipitate, the filtrate is treated with HCl to hold in solution any residual protein. Lactose, which was present in the original powder, in an amorphous condition, being supersaturated and insoluble in alcohol, now begins to crystallize. After crystallization is complete, the lactose is separated centrifugally. The alcohol is distilled from the mother liquor, the latter being high in riboflavin content.

When 70 per cent alcohol is used as solvent, 80 per cent of the lactose originally present in the whey is recovered as highly pure alpha lactose. With 95 per cent alcohol as solvent 60 per cent of the lactose in the whey powder in recovered as a very pure mixture of 1.3 parts of β lactose per part of α lactose.

Analytical data concerned with various phases of the process are presented.

B.H.W.

379. A Simplified Quinhydrone Electrode Application in Determining the H-ion Concentration of Liquids and Semiplastic Solids.

GEORGE P. SANDERS, Bureau of Dairy Industry, Washington, D. C. Ind. Eng. Chem., Analytical Ed., *10:* 5, 275, 1938.

A modified quinhydrone electrode, sample, tube, and calomel half-cell, which were developed chiefly for use on dairy food products, such as milk, whey, and cheese, are described. The electrode is a plain gold-plated platinum wire, and the conventional stopcock in the calomel half-cell is replaced by a sealed-in platinum wire. A simplified sample holder is described. B.H.W.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

380. Spray Drying. BEN B. FOGLER AND ROBERT V. KLEINSCHMIDT. Ind. Eng. Chem., *30:* 12, 1372–1384, 1938.

A comprehensive description of the important spray drying systems, and the principles and economics of their operation is presented. The Gray-Jensen unit commonly used in the drying of milk is included. There is a bibliography of the important patents on spray drying. B.H.W.

FEEDS AND FEEDING

381. The Nutritive Value of Alfalfa Proteins as Measured by Lactation in Rats. J. R. HAAG AND L. D. WRIGHT, Oregon Agr. Exp. Sta. Paper presented at the meeting of the Western Division of the American Dairy Science Association, October, 1938.

The growth of litters of six nursing rats was used as a measure of the ability of rats to lactate on rations containing approximately 9 per cent alfalfa crude protein. The lactation-promoting properties of such rations were enhanced by the addition of 0.4 per cent l-cystine. The average weight of the young produced on the alfalfa ration was 15 grams at 21 days. The average weight of the young produced on the ration supplemented with cystine was 25 grams. The lactating rats lost an average of 90 grams on the alfalfa ration and 50 grams on the supplemented ration. L.D.F.

382. The Utilization of the Nitrogen of Urea and Ammonium Bicarbonate by Growing Calves. E. B. HART, G. BOHSTEDT, H. J. DEOBALD, AND M. I. WEGNER, Univ. of Wis. Proc. Am. Soc. Animal Prod., *31:* 333–336. 1938.

Quite definite proof is offered that calves on low protein rations make use of urea and ammonium bicarbonate as measured by growth, composition of muscle, and computed storage of nitrogen. G.C.W.

383. The Effects of an Atypical Blindness Producing Ration upon the Vitamin K and C Content of Calf Blood. P. H. PHILLIPS, I. W.

RUPEL, J. J. OLESON, AND G. BOHSTEDT, Univ. of Wis. Proc. Am. Soc. Animal Prod., *31:* 320–327, 1938.

On a basal ration of white corn 22 parts, linseed oil meal 23 parts, wheat midlings 11.5 parts, and oat mill feed 40 parts, supplemented with ground limestone, iodized salt, and irradiated yeast atypical A deficiency symptoms developed. The addition of 100 micrograms of carotene per kg. of body weight produced normal growth and health. Without 25 cc. daily doses of Wesson Oil normal blood clotting was lacking, suggesting the need for vitamin K in the calf. G.C.W.

384. Effect of Decreased Body Reserves of Vitamin E on the Reproduction of Goats. G. K. UNDERBJERG, B. H. THOMAS, AND C. Y. CANNON, Iowa State College. Proc. Am. Soc. Animal Prod., *31:* 63–67, 1938.

As previously reported goats reproduced successfully on vitamin E free rations. Rats fed E depleted diets supplemented with milk, butterfat, muscle or adipose tissue of goats raised on depleted E rations failed in reproduction, whereas rats fed on E depleted diets supplemented with milk and tissues of goats raised on the usual farm ration reproduced successfully. G.C.W.

385. One Cause of Fat Variation in Milk. E. B. POWELL, Ralston Purina Co. Proc. Am. Soc. Animal Prod., *31:* 40–53, 1938.

The percentage of fat in milk of complete lactations of Holsteins was lowered from 0.5 to over 1.0 per cent by reducing the roughage markedly below the normal amount fed to lactating cows; and when hay was finely cut, or ground and cubed with a grain mixture, there was also a marked decrease in fat percentage. G.C.W.

386. Determination of Beta-Carotene in Alfalfa Meals. RICHARD C. BROOKE, STANLEY W. TAYLOR, AND WARREN S. BAKER, Writhmore Research Laboratory, Malden, Mass. Ind. Eng. Chem., Analytical Ed., *11:* 2, 104, 1939.

A method for the determination of beta-carotene in alfalfa products has been developed by modifying the Peterson and Hughes procedure. A special shaker to facilitate the extractions is described, and other steps in the method have been made adaptable to routine analysis. Beta-carotene was determined in the petroleum ether extracts by means of a photelometer. E.H.W.

FOOD VALUE OF DAIRY PRODUCTS

387. Vitamin D Potency of Human Breast Milk. ROBERT S. HARRIS AND JOHN W. M. BUNKER, Mass. Inst. of Tech., Cambridge, Mass. Am. J. Pub. Health, *29:* 7, 744, 1939.

A composite sample of 15 gallons of human milk contained only 4 USP XI units of vitamin D per quart. The authors conclude that the antirachitic superiority of human milk over cow's milk in infant feeding cannot be attributed solely to the quantity of vitamin D which it contains. It is possible to increase the antirachitic potency of human milk at least fivefold by feeding metabolized vitamin D milk to the lactating mother.

M.W.Y.

388. Studies on the Metabolism of Calcium and Phosphorus and on the Availability of These Elements from Milk and from an Inorganic Source. K. M. HENRY AND S. K. KON, Nat. Inst. of Res. in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Biochem J., *33:* 173, 1939.

Considerable effort has been already expended by a number of investigators to ascertain whether pasteurization affects the availability of calcium and phosphorous of milk, and whether calcium and phosphorous from inorganic sources are efficiently utilized as are those salts in milk.

Henry and Kon present a concise referential review of this problem in the light of experiments they had conducted on rats having varying degrees of body storage of the minerals.

In their studies it was observed that the calcium of milk was more available than the calcium from calcium acid phosphate, although under conditions of optimal utilization the difference is small. When excess phosphorus in the form of di-sodium phosphate was used, sub-optimal quantities of calcium were retained from spray dried milk with an efficiency of 98.1 per cent and from mono-calcium acid phosphate with an efficiency of 96.5 per cent, which difference is significant. K.G.W.

389. Vitamins of Elephants Milk. ZOFIA MARKUZE. Biochem. J., *33:* 198, 1939.

Elephant's milk has a lower content of vitamin A and D than does cow's milk. Its vitamin B content exceeds that of cow's milk by about twofold. Elephant's milk and cow's milk have about the same content of vitamin B_2 complex. Elephant's milk has about three and one-half fold the ascorbic acid content of cow's milk. K.G.W.

HERD MANAGEMENT

390. Effects of Climatic Factors on Live Stock. F. R. EDWARDS, Georgia Agr. Exp. Sta. Proc. Am. Soc. Animal Prod., *31:* 48–53. 1938.

Jersey cattle entered in the Register of Merit from Georgia and Maine over a 23 year period from the time if its adoption in 1903 were studied on the basis of the month of birth and butter fat yield. It was concluded that a cow conceived in December and January in Georgia and from October to

May in Maine has a chance of being a better producer than those conceived at other periods of the year. This is attributed to climatic effect during the uterine period. G.C.W.

391. Raising Dairy Calves in California. S. W. MEAD. Calif. Agr. Ext. Ser., Circular 107, April, 1938.

Directions are given for caring for young dairy stock divided into the following periods of their lives: from birth to two weeks of age, from two weeks to six months, from six months to one year, and from one year to the first calving.

Other sections include discussion of concentrates and roughages common to California, sanitation, quarters, common ailments together with means of prevention, and the place of vitamins and minerals in the ration. E.L.J.

392. The Distribution of Elements of Fertility between Feces and Urine in Dairy Cattle. K. E. HARSHBARGER AND W. B. NEVENS, Univ. of Ill. Proc. Am. Soc. Animal Prod., *31:* 58–61, 1938.

The distribution of N, P and K varied with the character of the ration, amount of food intake, and level of milk yield. The proportion of excreted N in urine varied from 32.3 per cent on a ration of clover hay and timothy hay, silage, and grain with a small amount of protein supplement, to 64.9 per cent on the same ration with a large amount of protein supplement. On the same type of ration the N in urine varied from 51.4 per cent when producing 45 lbs. of milk daily to 60.4 per cent when not lactating. On a ration containing timothy hay K dropped to 22.4 per cent in the urine when normally there is 2 to 3 times as much in urine as in feces. P in urine varied from 0.5 per cent to 6.8 per cent of the total excreted. G.C.W.

ICE CREAM

393. Overcoming Seasonal Variations in Ice Cream Sales. B. I. MASUROVSKY. Ice Cream Trade J., *35:* 6, 18b, 1939.

The author gives statistics showing that of the frozen products manufactured in a year, 24.09 per cent is produced in the spring, 43.90 per cent in the summer, 19.98 per cent in the autumn, and 11.53 per cent in the winter. He believes that sales should be stimulated in the winter so as to give less fluctuation in the quantity produced from one season to the next. In order to accomplish this end a chart is included which gives the special occasions of each month that might be capitalized on for sales stimulation. The leading flavors, new combinations of flavors, and timely fancy forms are given for each month. W.H.M.

394. Dull Scraper Blades Cost Industry Thousands Every Year. A. W. FARRALL. Ice Cream Trade J., *35:* 6, 33, 1939.

The author shows how dull scraper blades cut down freezer efficiency, and indicated a saving of 45 per cent in freezing and whipping time after dull blades were sharpened. Sharpening consists of two phases. First is the removal of the burr which must be done rather frequently. The use of a special sharpener is advised. Second is the dressing of the heel of the blade to the proper width, this being necessary at infrequent intervals.

W.H.M.

395. Development and Extent of the Frosted Foods Industry. M. A. SCHAARS, Univ. of Wisc., Madison, Wisc. Ice Cream Rev., *22:* 10, 52, 1939.

Today there are reported to be more than 100 companies freezing food products and using various forms of the four principal quick freezing methods (the immersion, the brine spray, the single plate and the multiple plate). The reported output of all frozen foods in 1937 was 370,933,100 pounds and the estimated output for 1938 is 480,000,000 pounds. In the rearrangement of food distribution, created by the frozen foods industry, the dairy and ice cream distributors stand a chance of playing a very important role. J.H.E.

396. Preserving Cream with Salt. O. E. WILLIAMS, U. S. Dept. Dairy Industry, Washington, D. C. Ice Cream Rev., *22:* 9, 36, 1939.

Cream can be preserved at room temperature without refrigeration for as long as eight days by the addition of 7 per cent sodium chloride. When preparing this cream for ice cream purposes milk is added to the salt cream mixture and the whole is subjected to temperature of approximately 120° F. The cream is then separated from the milk and salt, producing a plastic cream. Fresh milk is added in the proportion sufficient to restore the cream to the required butterfat content. The mixture is then pasteurized and cooled. J.H.E.

397. Creating Consumer Demand for Ice Cream through Advertising. FRANK BEACH, Univ. of Ill., Urbana, Ill. Ice Cream Rev., *22:* 10, 42, 1939.

The critics of advertising are saying that not enough real information is given to enable readers to buy intelligently and wisely. A well-planned advertising program on ice cream should set out to dispel the erroneous opinions many consumers have about ice cream. Other criticisms and also essentials for success in advertising are discussed. J.H.E.

398. Preparation of Sherbets and Ices. W. H. MARTIN, Kan. State College, Manhattan, Kan. Ice Cream Rev., *22:* 10, 38, 1939.

A review of the principles involved in the processing of sherbets and ices. J.H.E.

399. Ice Cream Cabinet Maintenance. B. LEWIS, Meese, Inc., Madison, Ind. Ice Cream Rev., *22:* 9, 31, 1939.

Suggestions are given for getting the best operating efficiency when installing a conversion unit in an old ice cream cabinet. J.H.E.

400. Ice Cream Cabinet Maintenance. R. W. WOODCOCK, Consumers Power Co., Saginaw, Mich. Ice Cream Rev., *22:* 10, 37, 1939.

The advantages of using an electric oven for dehydrating rebuilt and reconditioned sulphur dioxide ice cream cabinets are pointed out. This system enables removal of moisture before the system is charged. J.H.E.

401. Washing and Sterilizing Ice Cream Plant Equipment. H. A. ACKERMAN, Hydrox Corp., Chicago, Ill. Ice Cream Rev., *22:* 9, 52, 1939.

The selection of the proper cleaning agent should be given serious attention. The type of equipment, the material to be removed, and the hardness of the water must be considered. A chemical sterilizer should be selected that is stable in its original form and least corrosive to equipment. In ordinary work use a rinse solution of 100 p.p.m. Tanks should be sprayed with a solution of 300 p.p.m. J.H.E.

402. Some Seasonal and Unusual Types of Ice Cream Specials. D. A. HAASE, Walgreen Drug Stores, Chicago, Ill. Ice Cream Rev., *22:* 9, 41, 1939.

Experiences of a large company in the promotion of week-end ice cream specials are given. J.H.E.

403. Factors Affecting Costs. E. L. SCARAMELLA, Production Manager, Forward Dairy, San Jose, Calif. Ice Cream Field, *33:* 4, 1939.

Costs of manufacture and distribution of ice cream and its related products, sherbet and ice cream are shown. Costs were gathered in several plants over several years. Costs of making 12 per cent mix shown in detail at $0.6002 per gallon with a 40-cent butterfat market. Cost of manufacturing ice cream, shown in detail, show variation on finished cost, due to flavor, of $0.421 to $0.544 per gallon. Costs of manufacturing of ice milk shown as $0.3285 per gallon mix (40¢ lb. fat) and $0.2865 per gallon at $0.309. Affect of using increased serum solids in mix on finished cost of ice cream are shown, and calculations showing how it is brought about are given. The difference is shown to be about 6.1 cents per gallon. Delivery expenses are presented and divided into five classifications showing average costs to be 25 cents per gallon. Comparison of cost of manufacturing and distribution as developed in the article show a margin of 18.1 cents per gallon for ice cream, 34.1 cents per gallon for sherbets, and 6.3 cents per gallon for ice milk. E.L.S.

MILK

404. Use of Phosphatase Test in the Control of Pasteurization. PAUL F. KRUEGER, Board of Health, Chicago, Ill. Am. J. Pub. Health, *29:* 5, 477, 1939.

The phosphatase test, when originally applied, showed a relatively large proportion of samples of milk and cream to be improperly pasteurized, due principally to improper construction and operation of pasteurization equipment. In 88 milk pasteurization plants, 212 outlet valves and 146 inlet valves were defective when compared to the latest standards of the U. S. Public Health Service. Common defects in valves and methods for their correction are discussed in detail. M.W.Y.

405. Sanitary Condition of Paper Containers for Retail Packaging of Perishable Foods. J. R. SANBORN, New York State Agr. Exp. Sta., Geneva, N. Y. Am. J. Pub. Health, *29:* 5, 439, 1939.

This paper is based on bacteriological studies of seven types of paper containers for milk and milk products, and a study of the sanitary condition of the paper board out of which containers are made. During 1938, a marked improvement took place in the bacteriological condition of both paperboard and finished containers over results obtained in 1937. A majority of the containers yielded less than 5 bacterial colonies per container. M.W.Y.

406. The Plant of Tomorrow. V. SCHWARZKOPF, Vice-President, The Lathrop-Paulson Co. Milk Dealer, *28:* 8, 41, 46–52, May, 1939.

A discussion of the plant of tomorrow from the standpoint of new products, new materials, new methods, new machinery, etc. The following conclusions are drawn by the author:

We can view the future only by what has gone before. Human nature has not changed; human wants are ever greater and greater.

Business in the future as in the past can only survive if it is capable of earning a profit.

Profits can be made but it will require alert, aggressive, progressive management. In the struggle for profits we must not overlook the importance of a carefully planned, well-constructed, properly equipped plant.

In the future as in the past, obsolete methods, processes, plant and equipment will decrease or eliminate profits while improved methods, process and equipment will increase profits.

From 1919 to 1929 American industry spent over 210 billions of capital investment in the form of buildings, tools and equipment—an average of over 19 billions per year—and it produced the greatest period of profits we have ever experienced. Since 1929 the expenditures for capital investment

have averaged less than three billion dollars per year. America had been trying to progress without adequate tools and we have had one of the leanest periods we have ever experienced. It is estimated that it would require approximately 65 billions to catch up on our delayed capital investment program, a program to make American industry efficient and capable of meeting present-day requirements.

Each and every one is very much concerned about laws and regulations which restrict or retard business, but these are not our greatest hazard. Such laws and regulations in all probability apply with equal force to your competitors as well as to you. Therefore, you are still on the same competitive basis. But if you have an outmoded, obsolete plant or equipment or have an inefficient, wasteful system that requires excessive upkeep, power and labor, you are at a distinct disadvantage in competition with the up-to-date systems which other plants may have, and your profit margin will be sure to diminish or disappear. Your ability to meet new conditions to keep in tune with the times, to take advantage of new live facts will to a great degree determine your success. C.J.B.

407. Proportional Milk Sampler Patent Held by W. W. Fassett. Milk Dealer, *28:* 111, March, 1939.

In view of a previous article abstracted in this Journal (abstract 21, page A9, vol. 22), this note calls attention to a patent held by W. W. Fassett on a proportional milk sampling device. T.S.S.

MISCELLANEOUS

408. Some Suggestions for Cutting Fuel Costs. C. T. Baker, Atlanta, Ga. Ice Cream Rev., *22:* 10, 32, 1939.

Fuel wastes can be reduced by preventing excessive heat waste to the stack, providing a stack damper, preventing cold air from entering through cracks in the brickwork and providing suitable grates for the type coal burned. The importance of the recovery of condensate from steam traps, steam radiators, etc., is discussed. J.H.E.

PHYSIOLOGY

409. Effect of Pregnancy Urine Extract on Lactation in the Rat. I. L. Hathaway, H. P. Davis, R. P. Reece, and J. W. Bartlett, Depts. of Dairy Husbandry, Nebr. Agr. Exp. Sta. and N. J. Agr. Exp. Sta. Proc. Soc. Exp. Biol. and Med., *40:* 214, 1939.

Fifty-two lactating rats were employed in studying the influence of a pregnancy urine extract (Antuitrin-S) on lactation. The first injection was made shortly after parturition. The number of young in the litters was fixed at 6 and daily weighings were made. All of the animals were fed the

same ration. The injection of 100 r.u. of Antuitrin-S during the first 5 days of the lactation period caused no inhibition of lactation. Larger dosages and dosages over a longer period of time reduced the rate of growth of the young 22 to 33 per cent. R.P.R.

410. Effect of Testosterone on Pituitary and Mammary Gland. R. P. REECE AND J. P. MIXNER, Dept. of Dairy Husbandry, N. J. Agr. Exp. Sta. Proc. Soc. Exp. Biol. and Med., *40:* 66, 1939.

The daily injection of 200 gamma of testosterone propionate for 15 days into sexually mature spayed rats augmented the lactogen content of their pituitary glands about 40 per cent, caused no change in pituitary weight, induced an extensive development of the lobulealveolar system of the mammary glands, and initiated secretory activity. R.P.R.

411. Initiation of Lactation in the Albino Rat with Lactogen and Adrenal Cortical Hormone. R. P. REECE, Dept. of Dairy Husbandry, N. J. Agr. Exp. Sta. Proc. Soc. Exp. Biol. and Med., *40:* 25, 1939.

Pseudo-pregnancy was induced by injecting 100 r.u. of a gonadotropic principle into each of a group of multiparious rats. The injection was repeated 6 days later. On the 12th day following the induction of pseudo-pregnancy the animals were ovariectomized and a mammary gland removed. Various hormone preparations were injected subcutaneously every 8 hours until 6 injections had been made. Three or four hours following the last injection the animals were sacrificed and their mammary glands observed macro—and microscopically. Lactation was initiated by injecting lactogen plus the adrenal cortical hormone or lactogen plus the adrenal cortical hormone plus a 20 per cent glucose solution. R.P.R.

412. Effect of Estrogen Injections on Lactogen Content of Female Rat Pituitary. R. P. REECE, Dept. of Dairy Husbandry, N. J. Agr. Exp. Sta. Proc. Soc. Exp. Biol. and Med., *39:* 77, 1938.

The injection of Progynon-B into rats with their ovaries intact augmented the lactogen content of their pituitary glands. The pituitary glands from ovariectomized rats injected with 1000 i.u. Progynon-B daily for 15 days were significantly larger than those from rats with their ovaries intact and similarly treated, but the lactogen content per pituitary was similar. R.P.R.

413. The Effect of Continued Treatment with Anterior Pituitary Extracts on Milk Volume and Milk-fat Production in the Lactating Cow. S. J. FOLLEY AND F. O. YOUNG, Nat. Inst. for Res. in Dairying, Univ. of Reading, and Nat. Inst. of Med. Res., London, N.W. 3. Biochem. J., *33:* 192, 1939.

Repeated injections (12 on alternate days) of prolactin and thyrotropic preparations of fresh ox anterior pituitary lobes into cows in declining lactation results in a pronounced increase in milk yield, the increase being more marked with the prolactin preparations. The activity is evidently not due to the thyrotropic activity of the pituitary extracts, but rather due to prolactin activity (pigeon crop stimulating activity).

The increase in milk yield following injections of prolactin preparation was accompanied by an increase in milk fat content, and nearly 48 per cent fat yield for five successive administrations. With prolonged treatment with prolactin, a plateauing of milk production, and decline was observed.

No significant change was observed in the solids-not-fat content of the milk during the experiments, neither were there any significant variations in the lactose, chloride or phosphatase contents.

The authors conclude that the increase in milk yield and fat content of milk from cows in declining lactation following injection of pituitary extracts cannot be ascribed to a single substance. K.G.W.

Concerning

FRO-DEX

FRO-DEX* was originally conceived and developed specifically for use in ice cream, sherbets, and water ices, and was first introduced to the trade last October at the Dairy Industries Exposition. The immediate interest and the rapid adoption of FRO-DEX by many manufacturers have well demonstrated that the original plans and subsequent research were correct for producing a product (FRO-DEX) with a number of new and useful properties.

What is FRO-DEX?

FRO-DEX is a combination of pure cereal carbohydrates; namely, maltose, dextrins (pro-sugars), and dextrose, simultaneously produced from American corn.

Advantages of using FRO-DEX.

Because certain of the constituents of FRO-DEX have a higher molecular weight than the sugars commonly employed in ice cream production, FRO-DEX causes less freezing point depression and a quicker freeze is therefore possible.

The unusual combination of sugars resulting in FRO-DEX retards lactose precipitation and assures a resulting product of smooth texture and firm body.

Ice cream produced with FRO-DEX as an ingredient holds up much better in storage and dealers' cabinets. Sherbets and ices made with FRO-DEX do not separate syrup or crust over in storage or dispensing cabinets. Such interesting results are readily observed and are likewise easily understood when the physical properties of this unusual combination of sugars (FRO-DEX) are reviewed.

Due to its mellowing effect on ice cream, FRO-DEX enhances the true cream flavor of the dairy ingredients but at the same time contributes no flavor to the finished product.

Total solids can be increased economically and without the disadvantages of previously known methods.

How is FRO-DEX used?

Varying combinations of FRO-DEX and cane sugar are recommended, depending upon the type of resulting product desired.

We would be very glad to have you try FRO-DEX and to send you additional information. Address the Technical Service Division.

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A 10-page reprint (with cover) from the October, 1935, *Journal of Dairy Science*. Prepared by Subcommittee on Bacteriological Methods for the Analysis of Condensed and Evaporated Milk and Committee on Bacteriological Methods for the Analysis of Milk and Dairy Products.

and

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Second Edition

Consisting of 29 pages (also with cover) reprinted from the *Journal of Dairy Science*, May, 1933. Originally sold for 50 cents.

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Many schools are using these reports in their class work. They are up-to-date and will be found most useful for students.

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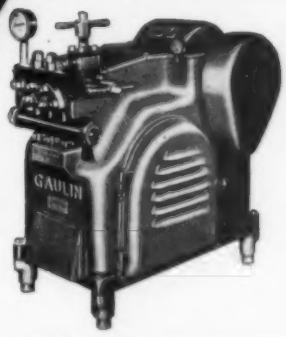

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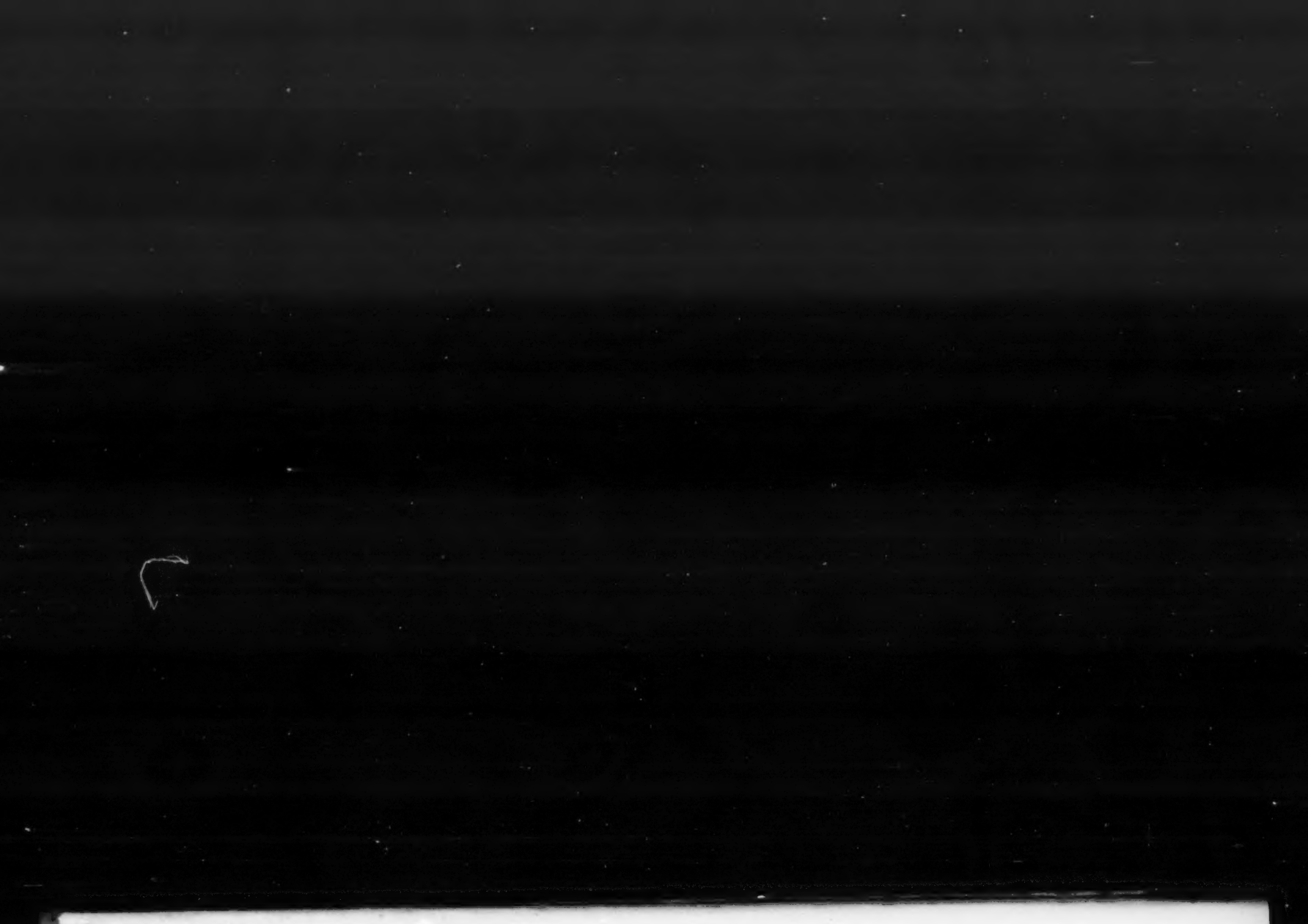

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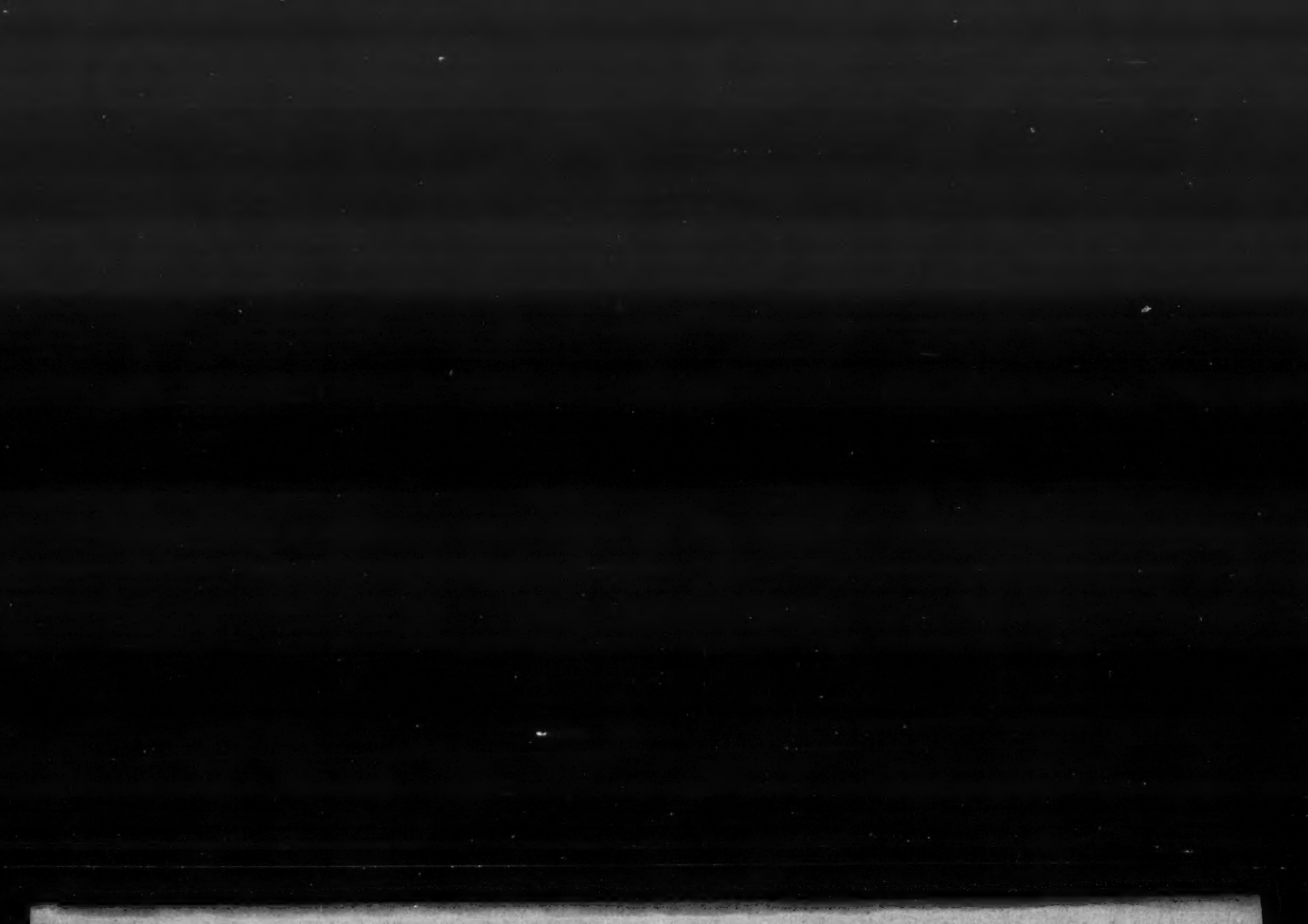
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